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Introduction.

THE Experimental and Research Station was inaugurated in 1914 under the auspices of the Nursery and Market Garden Industries' Development Society. From small beginnings, the Station has developed a fully equipped laboratory, housing a scientific staff able to deal with the problems which may be submitted by growers from time to time. In addition there are six cucumber houses, twelve tomato houses and two glasshouses for entomological work.

It is hoped that funds may be forthcoming in the near future to permit the erection of glasshouses for crops other than cucumbers and tomatoes. The Station will then be in a position to experiment with such crops as grapes, roses, carnations, ferns, melons and mushrooms, as well as certain decorative pot plants.

Anyone able and willing to finance this project would be a public benefactor, for the Station, started to benefit a local industry, now serves the nation, and the need for experiments with all glasshouse plants is becoming increasingly greater each year.

Membership of the Society, under whose auspices the experiments are conducted, is open to all growers and interested persons, and subscriptions are payable at the rate of two guineas for each acre of glass cultivated by the subscriber ; in return members receive future publications and any advice which is available. Members are constantly being enrolled, but many more are needed, both to provide additional funds for research and to obtain complete co-operation in controlling the various pests and diseases common to glasshouse plants. Serious outbreaks over a wider area must be fought by all growers ; isolated attacks are bound to fail.

Evening Discussions.

The evening lectures for nursery owners and employees, commenced in 1925 at the request of the workers, were continued during the present year, the subjects selected being as follows :—

1928.

Nov. 14th.—Garden Pests. Mr. E. R. Speyer.

Nov. 28th.—Bulbs. Mr. E. A. Bowles.

Dec. 12th.—Boilers. Mr. C. H. Shoults.

1929.

Jan. 9th.—Recent experiences with Cucumbers and Tomatoes. Mr. E. Vogel and Mr. F. Russell.

Jan. 23rd.—Roses. Mr. W. E. Chaplin.

Feb. 6th.—Some Cucumber and Tomato Experiments. Dr. W. F. Bewley.

Feb. 20th.—Anemones. Mr. E. A. Bowles.

Grants.

A special grant has been generously provided by the Empire Marketing Board for the fundamental investigation of virus diseases, chiefly Mosaic disease of the cucumber and the tomato. This included a capital grant of £1,040 for erecting an experimental glasshouse, and a maintenance allowance of £1,200 per annum. The Lea Valley Growers' Association has also continued the grant of £200 per year for the purpose of investigating infestations of the Red Spider Mite on commercial nurseries.

Our sincere thanks are tendered to these bodies for their generous assistance.

Current Investigations.

Manurial and crop management trials with tomatoes have been continued.

The experiments to test the effect of different amounts of stable manure per acre have been continued since 1926 and, as in previous years, 15 tons per acre have proved as effective as larger amounts.

The substitution for stable manure of wheat straw or bean straw has been continued and it would appear that this substitution can be made at intervals without affecting the crop. The application of wheat straw in addition to stable manure improved the crop but some reduction in yield occurred when stable manure and bean straw were applied together.

An increase in crop was obtained by treating the soil previously with formaldehyde and taking a crop of tulips prior to tomatoes. The increase was only slight where this treatment had been applied in 1928.

The experiments in which lime was withheld from soil deficient in carbonates were repeated. As in 1928, the plots without lime produced a heavier crop than the limed plots.

During 1928 applications of a top-dressing fertiliser at the rate of 2 ozs. per sq. yd. were compared with those of 1 oz., the result being in favour of the heavier dressing. The experiment was repeated during the present season ; no difference in crop was obtained. The investigation will be continued.

The watering experiments of 1928 were repeated with slight variation. Two plots were watered with a hose in the usual way, two were watered through underground pipes, while in two the plants were set out in shallow trenches which served to collect the water round the immediate vicinity of the plant. Two plots were hoed regularly through the season. The results were in favour of planting in trenches and watering by buried pipes. In the latter case, however, it was necessary to cease the application of water from below after the beginning of June, because the lower region of the soil became water-logged and some yellowing appeared on the foliage. The bottom crop was excellent, and there are indications that subterranean watering is of considerable importance at the beginning of the season, but it requires more water than the ordinary hose method.

In 1928 crosses were prepared between the tomatoes Stirling Castle and E.S. 1, and Up-to-date and E.S. 1, Stirling Castle and Up-to-date being highly resistant to *Cladosporium fulvum*. The F_2 generation were tested in Tomato House 1. Unfortunately, Mildew was not sufficiently serious to provide a reliable test of resistance, and further the quality of the fruit produced by the plants was poor. Further crosses with other varieties have been prepared and the progeny will be examined in 1930.

The investigations of the temperature requirements of the tomato, commenced in 1928, were continued. The evidence obtained in 1928 indicated that with E.S. 1 a night temperature between 63°F, and 65°F. was necessary for the best results. During the present season, using the variety Craigwood, similar weights were obtained at minimum night temperatures of 60°F. and 65°F.

The process of warming soils by resistance wires heated electrically has been further examined, but unfortunately only one coil survived until the end of May, the others on examination proved to be corroded. The only plot heated by this method was held at a temperature of 82°F. during April and May. A crop of 59 tons per acre was obtained representing an increase of 10 tons per acre over the control. The question of soil temperature is most important for nurserymen, and every effort will be made to devise some cheap method of warming the borders.

A general survey of the temperature conditions prevailing in glasshouses was begun during the current year. Comprehensive records were taken of soil and air temperatures in different parts of two tomato houses ; one the old vinery type and the other the newer "aeroplane" type with high gutters.

The cucumber experiments were designed to test the effect of opening the beds by the addition of various spongy materials.

The addition of peat moss even in the presence of lime proved harmful. In previous years the crop has been improved by incorporating straw and bean straw with the

beds, but during the present season they were without effect. Excellent results have been obtained by cultivation in beds made up mainly of soil and straw.

Sterilisation of the base by steam again increased the crop considerably, the greatest increase occurring in plots 4—6, House G, where last year's beds were dug into the base prior to steaming.

Cucumbers were again grown under glass which transmitted part of the ultra violet rays of the sun in the south half of a house fitted with ordinary glass in the other half. The crop was only 5 per cent. greater under the ultra violet transmitting glass than under ordinary material. Last year an increase of 25 per cent. was recorded.

The Red Spider investigations have been continued. The value of naphthalene fumigation in the Autumn and the early and systematic spraying of the plants with petroleum emulsions throughout the season has been confirmed on commercial nurseries.

The examination of the action of volatile substances on the Red Spider Mite has been continued and, in addition, the activities of several series of compounds have been determined under standardised conditions to obtain information concerning the influence of chemical constitution upon insecticidal properties. In the case of the aliphatic alcohols and their formic esters it has been found that, with the exception of methyl formate, the activity increases with increasing molecular weight and that normal compounds are more active than their isomers.

Samples of "low temperature tar" phenols from the Department of Scientific and Industrial Research have been emulsified and tested. Samples from which the phenate soluble constituents were not removed were slightly more active than the purified samples. Their use as a control for the mite is impractical in view of their injurious effect on the host plant.

The possibility of substituting vegetable oil emulsions for the emulsified petroleums, at present used in the commercial control of the Red Spider Mite, has been

investigated. For use with soft water satisfactory emulsions can be made with soft soap and yield an efficient control when the spray fluid contains 1 part of oil in 120. A more efficient spray may be made by using proprietary emulsifying agents of the sulphonated-oil type. In this case the necessary amount of emulsifying agent is dissolved in the oil, and alkali added to the water in the spray tank. The emulsion is then formed by adding the required amount of oil to the water and stirring.

The Chalcid parasite, *Encarsia formosa*, is becoming a popular means of controlling White Fly in glasshouses. Its distribution has been continued through the season. Considerably over a million parasites have been distributed from the Station, and applications were so numerous that it was impossible to supply all the material required. It is anticipated that the demands will increase to such an extent that the present accommodation for breeding the parasite will prove hopelessly inadequate.

The relation of leaf mould, *Cladosporium fulvum*, to environmental conditions was studied on commercial nurseries during the past season; temperature and humidity records were taken by thermo-hygrographs, and notes were made concerning the appearance and development of leaf mould, ventilation, watering, etc. Omitting the sunny periods, 20th to 26th May, 1929, and 8th to 24th June, 1929, the weekly average temperature was well below the optimum for leaf mould (72°F.) till the end of August. The weekly average humidity was usually 75-85 per cent.; the weekly average maximum humidity was 90-95 per cent.; and on dull or rainy days the humidity was 80-90 per cent.

Night ventilation varied considerably on different nurseries; in many cases little was given till July, and the ventilators were closed throughout the entire season.

Leaf mould was far less severe than in other years. As a rule soft forced plants which developed quickly suffered most.

Experiments have suggested that the mode of infection is not exclusively stomatal, and that the fungus may cause considerable reduction in yield by attacking the flower trusses.

The spores of *C. fulvum* have been found to overwinter in glasshouse structures and in the soil. It has been shown also that the spores of this fungus may be destroyed by burning sulphur in the house or spraying with emulsified cresylic acid. This suggests that glasshouses may be freed from infection by such methods. The investigations are being continued.

An examination is being made of the microflora of the soil of a house devoted to manurial experiments. Bacterial counts throughout the season suggest that variations in the manurial treatment are not reflected in the numbers of bacteria present at a given time, with the exception of plots receiving no manure and stable manure respectively, the latter showing a temporary large increase in the early part of the season. A point of importance is the sudden fall in the numbers following the first heavy watering, suggesting the carrying down of the bacteria to lower levels of the soil. In the early part of the season the numbers of actinomycetes varied inversely with that of the bacteria, but later followed them more closely. Fungi were relatively scarce, the highest number being recorded in plots receiving stable manure, and artificials without nitrogen. The highest numbers were recorded in May.

Attention has also been paid to fungi causing "Damping off" of tomatoes and cucumbers. Three species of *Phytophthora* are concerned, one of which was formerly thought to attack the cucumber only. It has now been found on the tomato, especially in the young stages.

P. parasitica and *P. cryptogea* which commonly attack the tomato have been found to infect cucumber seedlings in the early stages.

It has been shown conclusively that Mosaic disease of both tomatoes and cucumbers is frequently carried by the seed. Stocks of clean seed have been obtained by

systematic roguing of infected plants. When this seed was used and simple precautions were taken to prevent re-infection, the crops were clean.

The effect of treating tomato seeds with the common seed disinfectants and of exposing them to wet and dry heat has been investigated. It has been found that they will stand relatively high temperatures after systematic pre-heating.

A new method for extracting tomato seeds by the addition of sodium carbonate to the pulp and seeds has been devised,

Last year it was reported that considerable damage to tomato plants had been traced to the presence of chlorates in the soil. In an attempt to account for these compounds all the artificial fertilisers ordinarily used have been examined for chlorates. None of the samples examined contained chlorates.

Several soils submitted for analysis and containing granules of calcium carbonate, have been found to give a positive acid reaction in Comber's test. The attention of growers has been drawn to the desirability of ensuring thorough mixing of lime with the soil.

Steaming has been shown to minimise the effects of manurial deficiencies on the tomato crop, and analyses made this year show that this is accompanied by some degree of uniformity in the composition of the foliage of plants growing in the different plots.

DIRECTOR'S REPORT.

1. Experimental Results of 1929.

The practice of grading the tomato fruits from the experimental plots, adopted in 1921, was continued during the present season. The fruits were collected in numbered baskets, and graded in eight grades as follows:—

A.—"Pinks" number 5 to 7, and "Pink and White" 8 to 10 to the lb. These are the best quality of fruit in size, shape, and colour; "Pinks" being slightly larger than "Pink and Whites."

B.—"Whites." These fruits are of good colour, but smaller than "Pink and Whites."

C.—"Blues." This grade consists of fruit of good colour, but larger and more irregular in shape than Grade A.

D.—"Roughs." Small mis-shapen fruits about the size of cherries.

E.—Blotchy fruits which ripen irregularly.

F.—Fruit showing Blossom End Rot.

G.—Fruits showing the lesions of Stripe Disease.

H.—Fruits showing "Green Back."

1. Tomatoes.

(a) Houses 3 and 4, Fertiliser Experiment.

Many important facts concerning the nutrition of the tomato have arisen from these experiments, which were commenced in 1919. Since 1926 the plots have shown severe signs of ageing, and after due consideration, it was decided to terminate the present experiments at the end of 1929. The soil in House 3 has been removed to a depth of 18 inches and substituted by good turfy loam from a clean field. House 4 has been treated similarly, except that six half plots ($12\frac{1}{2}$ feet by $12\frac{1}{2}$ feet) of the experimental soils have been

arranged at the north end of the house as a permanent demonstration of the effect of the following treatments applied continuously :—

(1) Complete artificials.
(2) Complete artificials with stable manure.
(3) Complete artificials less phosphate.
(4) Complete artificials less nitrogen.
(5) Complete artificials less potash.
(6) No manure.

The new set of experiments, starting with 1930, are arranged to test the relative effects of various nitrogenous fertilisers on the tomato crop.

Before removing the old soil, it seemed desirable to collect as much information as possible from the most important plots. To this end a reasonably complete analysis of the soil and its fungus and bacterial population was undertaken. An attempt was also made to determine what animals were present in the different plots; this was soon discontinued in view of the uniformity of the fauna of different plots.

At this point it is convenient to summarise the results of fourteen years' experiments and endeavour to extract the useful information they provide.

The omission of nitrogenous fertilisers.

The plants in J7 and K7, from which nitrogenous fertilisers have been withheld since 1916, have presented a characteristic appearance since 1919, when signs of nitrogen deficiency first became noticeable. Plants in these plots are stunted, with thin weak stems, pale foliage and small leaves. The flower trusses bear fewer flowers than those on normal plants. The flowers set freely and swell rapidly but attain a relatively small size. Typical yellow areas develop between the veins and enlarge until the entire leaf is involved. The leaves are relatively thin and the yellow areas soon dry up and turn brown. The colour of the fruits is yellowish red and ripening is uneven and blotchy.

During the first four years the omission of nitrogen increased the crop compared with that from the complete artificial plot, but from 1922 onwards the crop has gradually decreased. The highest yields of 47 tons per acre (J7) and 50 tons per acre (K7) occurred in 1919, the lowest being 16 tons per acre (K7) in 1929.

The symptoms, slight at first, gradually increased in severity until in the later years most of the plants produced only two good trusses and were dead by the end of July.

The omission of potassic fertilisers.

Symptoms of potash deficiency began to appear in 1919 on the two plots J8 and K8. The plants are generally stronger than those from the nitrogen starved plots. They are relatively dark green in colour, often with a decided tinge of purple and soon show the typical yellowing and drying so characteristic of potash deficiency. At first the edges of the leaves turn a pale green colour, which quickly changes to yellow and finally the tissues become dry and turn brown. The yellowing and drying proceed gradually towards the centre until the entire leaf is affected. In this way the symptoms of potash deficiency are opposed to those of nitrogen starvation, where the yellow areas arise in the centre of the leaves and spread outwards.

Plants receiving insufficient potash are highly susceptible to "stripe" disease and show a remarkably high proportion of blotchy ripening. Further, the red colour of the fruits is not so bright in appearance as that in normally manured plants. Also the crop yield from these plots has been consistently below that from the complete artificial plot.

The omission of phosphate.

The plants in plots J6 and K6, from which phosphates have been withheld since 1916, have been carefully examined by many independent observers, who have invariably failed to discover any untoward effect of the treatment. The general appearance of the plants, the quality of the fruit and the weight of the crop all suggest that, under the conditions prevailing in the experimental houses, the continual addition of phosphate is unnecessary.

Complete artificials.

The average crop yields from 1916 to 1924, a period before the ageing of the plots became an important factor, suggests that there is little advantage in adding stable manure to the dressing of complete artificials or indeed of increasing it. This is shown by comparing the average yields from plots receiving complete artificials, twice this dressing, complete artificials with stable manure and complete artificials with Lea Valley standard. The excessive dressing given in the double complete artificial plot proved harmful.

Blotchy ripening of tomato fruits.

In the Eleventh Annual Report "Blotchy" ripening in relation to manurial treatment has been fully discussed. It was shown that this disorder is the result of malnutrition in

Table 1.

Crop yield in tons per acre.

TOMATO HOUSE 3 (SERIES J).										TOMATO HOUSE 4 (SERIES K).								
Year	Variety.	2C.A.	C.A. + st'nd-ard.	C.A.	C.A. + Stable manure.	C.A. less phos-phates.	C.A. less nitro-gen.	C.A. less potash.	Unman-ured.	Variety.	2C.A.	C.A. + st'nd-ard.	C.A.	C.A. with stable manure.	C.A. less phos-phates.	C.A. less nitro-gen.	C.A. less potash.	Unman-ured.
1916	Comet ...	41·8	41·8	35·7	43·3	36·5	42·6	42·6	42·6	Kondine Red	47·1	43·1	38·8	38·8	40·3	43·1	43·1	46·4
1917	,, ...	28·2	38·0	35·8	32·5	34·9	39·2	32·5	37·5	,, ,,	36·1	40·1	39·5	40·0	40·8	42·5	36·2	37·3
1918	,, ...	22·5	25·4	25·8	26·8	24·8	28·2	21·5	21·7	,, ,,	25·3	30·7	32·1	28·5	28·1	32·8	26·3	27·1
1919	,, ...	38·1	41·1	44·2	43·1	42·7	47·4	39·3	37·9	,, ,,	42·8	43·5	46·5	44·3	43·7	50·3	43·3	42·6
1920	,, ...	26·2	29·1	27·4	28·9	26·4	28·3	24·7	27·7	,, ,,	29·4	34·3	39·2	38·4	34·9	35·3	34·0	36·5
1921	,, ...	30·5	33·6	32·4	35·8	30·0	33·9	36·9	36·5	,, ,,	36·0	39·9	46·3	41·4	41·1	43·9	45·5	46·5
1922	,, ...	31·5	29·8	32·7	29·5	36·6	27·5	31·4	25·7	,, ,,	40·5	41·5	43·1	43·3	38·2	40·0	42·2	30·8
1923	Manx Marvel	37·1	42·9	38·7	43·0	38·1	35·6	34·3	32·9	Manx Marvel	32·8	40·1	41·0	38·9	36·3	35·7	35·7	25·5
1924	,, ,,	43·6	43·7	46·4	45·0	44·6	40·6	45·0	33·1	,, ,,	37·4	39·3	41·2	38·3	38·1	32·9	31·8	24·3
1925	,, ,,	36·7	40·3	40·6	41·1	43·9	30·0	28·5	26·6	,, ,,	33·4	31·2	35·3	27·2	33·7	24·7	28·4	19·1
1926	,, ,,	—	—	28·1	—	32·8	22·7	27·4	21·4	,, ,,	25·8	30·9	29·9	29·6	32·8	23·6	22·8	19·5
1927	,, ,,	—	—	30·9	—	30·9	26·1	25·3	19·7	Water Baby	35·3	34·8	34·7	32·6	34·1	30·5	25·9	24·3
1928	,, ,,	—	—	31·9	—	36·3	32·1	28·0	26·9	E.S.1 × Comet	28·0	25·6	29·3	26·4	27·4	19·5	22·7	17·9
1929	,, ,,	—	—	32·5	—	33·1	25·8	31·2	14·0	Water Baby	28·8	29·6	32·5	25·6	29·0	16·0	17·3	14·5
Av. yield 1916-1924		33·3	36·2	35·5	36·4	34·9	35·9	34·2	32·8		36·4	39·2	40·8	39·1	37·9	39·6	37·6	35·3

Table 2.

The percentage of "Blotchy" fruits.

TOMATO HOUSE 3 (SERIES J).							TOMATO HOUSE 4 (SERIES K.)						
Year.	Variety.	C.A.	C.A. less phos-phates.	C.A. less nitro-gen.	C.A. less potash.	Unman-ured.	Variety.	C.A.	C.A. with stable manure.	C.A. less phos-phates.	C.A. less nitro gen.	C.A. less potash.	Unman-ured.
1921	Comet	12·73	8·75	27·65	31·83	47·18	Kondine Red ...	5·83	4·79	6·37	23·99	24·23	57·16
1922	,, ...	—	—	0·28	1·52	8·64	,, ,, ...	0·37	0·92	0·21	7·15	20·15	36·65
1923	Manx Marvel ...	2·16	1·60	10·23	22·39	25·17	Manx Marvel ...	2·59	2·01	2·52	8·73	18·12	18·45
1924	,, ,, ...	0·32	2·22	3·75	18·07	51·05	,, ,, ...	—	0·21	0·61	2·07	12·21	24·45
1925	,, ,, ...	0·94	0·71	0·60	23·04	33·23	,, ,, ...	—	0·41	1·35	8·92	24·87	43·25
1926	,, ,, ...	6·21	5·80	9·71	24·09	43·04	,, ,, ...	4·17	4·09	4·63	12·98	32·98	39·44
1927	,, ,, ...	1·46	0·49	7·26	37·81	35·89	Water Baby ...	0·43	0·46	1·11	5·23	12·03	29·38
1928	,, ,, ...	2·47	4·41	13·04	35·85	16·10	E.S.1 × Comet ...	1·54	1·04	0·26	1·58	17·74	23·43
1929	,, ,, ...	2·58	2·06	14·10	28·05	47·20	,, ,, ...	0·25	0·31	0·78	3·31	45·61	22·91

respect of potash and nitrogen, especially the former, and that phosphates are practically unimportant. The proportion of "Blotchy" fruits in a tomato crop can be reduced to a minimum by suitable applications of sulphate of potash and sulphate of ammonia. Blotchy ripening has not been eliminated entirely by manurial treatment; other factors, probably climatic in nature, play some part in the incidence of this disorder. Certain root diseases and too dry a soil are also important for they prevent the plant from absorbing sufficient nutrients from the soil to assist correct ripening.

These facts are further confirmed by later records as may be seen from Table 2.

The effect of increasing amounts of phosphatic, nitrogenous and potassic fertilisers.

Table 3 presents the results of seven years' experiments in connection with the application of various amounts of the essential nutrients to the tomato crop. Previous to 1923 the particular nutrient under test had been withheld since 1916. Thus the plot receiving no phosphate in 1923 had received none since 1915, and those receiving 8%, 16% and 24% respectively had their first dressing in 1923.

It will be seen that under the Experimental Station conditions the addition of phosphate seems unnecessary, for it affects to an appreciable extent neither the crop nor the quality of the fruits.

The addition of nitrogen to land deficient in this nutrient leads to improved quality of the fruit and an increase in crop. The results suggest that the nitrogenous part of a tomato fertiliser may be increased to 7½% nitrogen (as ammonia) with advantage.

The results of the potash series have illustrated the great importance to the tomato of this fertiliser. It increases its resistance to "stripe" disease, improves the quality of the fruit and generally assists to improve the balance of growth towards increased fruitfulness.

Generally, 7½% potash in a fertiliser mixture provides the maximum crop, but as 10% potash is necessary to reduce "Blotchy" ripening of the fruits to a minimum it is suggested that a good tomato fertiliser must contain the higher percentage.

Thus, by comparing the results of the above three sets of experiments it is suggested that a satisfactory tomato fertiliser should contain 7½% nitrogen as ammonia, and 10% potash as K_2O. To this may be added 5% soluble phosphates as $Ca_3(P.O_4)_2$ to satisfy a minimum demand for phosphate.

Table 3.

The effect of increasing amounts of phosphates, nitrogen and potash, 1923–1929.

Fertiliser.	1923.		1924.		1925.		1926.		1927.		1928.		1929.	
	Tons per acre.	% Blotchy fruit.	Tons per acre.	% Blotchy fruit.	Tons per acre.	% Blotchy fruit.	Tons per acre.	% Blotchy fruit.	Tons per acre.	% Blotchy fruit.	Tons per acre.	% Blotchy fruit.	Tons per acre.	% Blotchy fruit.
Phosphates 0 ...	38·08	1·60	44·60	2·22	43·87	0·71	32·75	5·80	30·85	0·49	36·25	4·41	33·56	2·06
,, 8% ...	33·67	0·68	44·53	1·36	—	—	32·15	3·30	33·86	0·69	35·03	2·60	31·69	1·67
,, 16% ...	34·89	2·61	44·60	0·18	41·27	0·36	31·08	4·38	29·79	1·78	37·31	2·04	31·69	3·12
,, 24% ...	33·14	2·98	47·92	0·44	41·19	0·19	32·60	2·33	34·81	1·75	37·69	1·62	36·10	1·88
,, 32% ...	—	—	—	—	41·81	0·19	—	—	—	—	—	—	—	—
Nitrogen 0 ...	35·64	10·23	40·56	3·75	30·00	6·60	22·65	9·71	26·14	7·26	32·07	13·04	29·76	14·17
,, 1¼% ...	43·40	4·73	48·72	0·78	—	—	—	—	—	—	—	—	—	—
,, 2½% ...	38·15	3·98	51·00	0·16	34·73	—	—	—	—	—	—	—	—	—
,, 5 % ...	41·80	2·00	53·88	0·27	39·45	0·76	32·83	7·65	33·89	4·48	28·57	9·31	—	—
,, 7½% ...	—	—	—	—	43·93	0·70	33·67	4·51	29·71	1·52	27·81	12·59	37·62	9·09
,, 10 % ...	—	—	—	—	—	—	31·97	3·31	32·91	1·39	33·06	9·20	37·16	7·92
,, 12½% ...	—	—	—	—	—	—	—	—	—	—	—	—	43·24	5·27
Potash 0 ...	34·28	22·39	45·00	18·07	28·51	25·04	27·43	24·09	25·31	37·81	27·97	35·85	31·16	29·37
,, 2½% ...	35·87	12·50	45·19	6·22	—	—	—	—	—	—	—	—	—	—
,, 5 % ...	36·86	12·16	46·73	4·39	40·97	4·08	—	—	—	—	—	—	—	—
,, 7½% ...	44·68	14·80	50·99	3·57	41·21	2·98	33·28	13·25	32·37	5·62	25·53	30·68	34·58	12·76
,, 10 % ...	—	—	—	—	41·80	0·96	32·90	8·08	32·75	2·32	28·42	19·27	33·74	11·27
,, 12½% ...	—	—	—	—	—	—	35·34	8·38	35·49	0·65	33·66	11·73	33·66	8·79

The effect of phosphate, nitrogen and potash in relation to weather conditions.

Observation has not ceased to suggest that the effect of potassic and nitrogenous fertilisers is so affected by prevailing weather conditions that mere "rule of thumb" and mechanical applications are certain to yield unexpected results. It is common knowledge that nitrogenous fertilisers tend to assist vegetative growth and that, in excess, the balance is thrown so much to the side of stem and leaf production that both the total crop and size of fruit is reduced. Moreover the fruits tend to be soft and irregular in shape. It is also known that vegetative growth is more luxuriant in dull, wet weather, especially if the temperature is high. Therefore on first principles it would seem that nitrogenous fertilisers should be reduced under the latter conditions.

Similarly potassic fertilisers tend to ripen or mature the plant, an excess producing hard woody stems, small leaves and reduced foliage. As abundant sunshine acts in a similar manner, it may be assumed that potassic fertilisers are least important during fine sunny summers.

Confirmation of this was sought in the results obtained by withholding phosphates, nitrogen, and potash. For this purpose the yields obtained from 1917 to 1923 were selected because the ageing effect shown in later years had not begun. The weights in tons per acre were expressed as percentages of that given by treatment with complete artificials, and plotted against the total hours of bright sunshine between April 1st and September 30th in any year.

The result of this is shown in Fig. 1, where the percentage crops are set out along the vertical axis, and total hours of sunshine along the horizontal axis. On inspection it may be seen that there is no reason to assume any marked deviation from the straight line form in the three curves, and the three straight lines were therefore obtained by "the method of least squares."* It will be seen from these curves in Fig. 1, that the crops obtained when either nitrogen or phosphate is withheld are not appreciably affected by bright sunlight, whereas that obtained by withholding potash increases in proportion to the total hours of bright sunlight between April 1st and September 30th. This suggests that growers may with advantage increase their applications of potash during dull wet weather and reduce them in bright sunny summers.

* The method of least squares in a mathematical device whereby the most probable equation or graph corresponding to a number of experimental results is obtained, thus avoiding any personal bias.

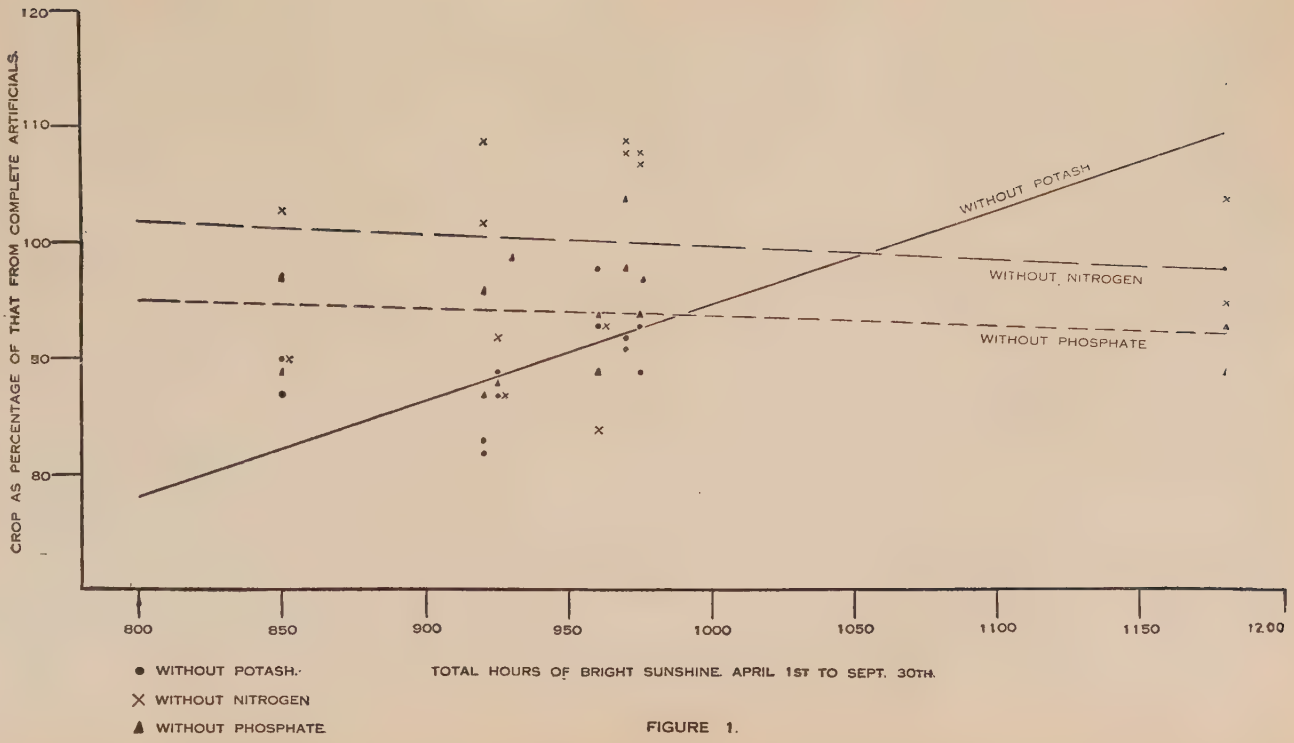

120
110
100
90
80
CROP AS PERCENTAGE OF THAT FROM COMPLETE ARTIFICIALS.
WITHOUT POTASH
WITHOUT NITROGEN
WITHOUT PHOSPHATE
800
850
900
950
1000
1050
1100
1150
1200
TOTAL HOURS OF BRIGHT SUNSHINE. APRIL 1ST TO SEPT. 30TH.
● WITHOUT POTASH.
× WITHOUT NITROGEN
▲ WITHOUT PHOSPHATE

FIGURE 1.

Plot.	Treatment during 1929.	Grade of Fruit: Percentage.								Total.	
		A.	B.	C.	D.	E.	F.	G.	H.	Lbs. per plant.	Tons per acre.
1a	*See* footnote	84·05	13·18	0·20	1·44	0·93	—	0·20	—	4·26	32·37
1b	As 1a but dried blood replaced by top dressing mixture	85·44	12·03	—	0·98	1·55	—	—	—	3·91	29·71
1c	As 1a, but two dressings of sulphate of potash omitted	83·50	12·98	0·88	1·47	0·59	0·29	0·29	—	3·39	25·76
1d	Top dressing mixture throughout the whole season	81·50	14·28	0·26	2·38	1·32	—	0·26	—	3·78	28·72
2a	Unmanured	71·19	14·04	1·84	1·11	10·71	—	—	1·11	2·71	20·59
2b	14 lb. stable manure per sq. yd. in 1925, none since	48·64	17·73	—	—	32·29	—	0·45	0·89	2·20	16·72
2c	28 lb. stable manure per sq. yd.	32·63	15·76	1·08	—	47·26	—	—	3·27	1·84	13·98
3a	Sulphate of potash only	80·64	12·52	2·93	0·98	2·93	—	—	—	5·11	38·83
3b	2½% nitrogen and 10% potash	83·88	11·18	1·05	0·84	0·83	—	0·21	—	4·74	36·02
3c	5% nitrogen and 10% potash	84·21	13·22	0·43	1·92	0·22	—	—	—	4·69	35·64
3d	7½% nitrogen and 10% potash	85·12	11·74	0·39	0·79	1·96	—	—	—	5·09	38·68
4a	5% phosphate and 10% potash	76·68	13·96	1·14	1·60	6·62	—	—	—	4·37	33·21
4b	2½% nitrogen, 5% phosphate and 10% potash ...	80·03	15·81	0·21	1·51	1·79	0·44	0·21	—	4·49	34·12
4c	5% nitrogen, 5% phosphate and 10% potash ...	80·63	13·83	0·43	1·71	1·49	0·21	1·49	0·21	4·70	35·72
4d	7½% nitrogen, 5% phosphate and 10% potash ...	80·28	16·10	0·20	1·61	1·61	—	0·20	—	4·97	37·77
5a	Complete artificials (Formula II.) with grass ...	75·68	16·37	2·57	2·34	2·57	—	0·47	—	4·28	32·53
5b	Complete artificials (Formula II.)	72·99	15·94	4·43	2·44	3·76	0·22	0·22	—	4·51	34·27
6a	Complete artificials without phosphates	82·55	13·32	0·69	1·38	2·06	—	—	—	4·35	33·06
6b	8% phosphates	81·54	14·39	0·72	1·20	1·67	0·24	0·24	—	4·17	31·69
6c	16% phosphates	78·18	15·34	0·96	2·16	3·12	—	0·24	—	4·17	31·69
6d	24% phosphates	77·90	16·21	1·26	1·69	1·89	0·42	0·63	—	4·75	36·10
7a	Complete artificials without nitrogen	68·16	12·96	2·06	2·06	14·17	—	0·59	—	3·39	25·76
7b	7½% nitrogen	71·52	11·42	4·44	2·22	9·09	—	1·11	0·20	4·95	37·62
7c	10% nitrogen	73·13	11·83	4·86	1·64	7·93	—	0·61	—	4·89	37·16
7d	12½% nitrogen	75·55	11·96	5·28	1·76	5·29	0·17	—	—	5·69	43·24
8a	Complete artificials without potash	57·10	10·73	1·95	0·73	28·03	—	0·24	1·22	4·10	31·16
8b	7½% potash	70·10	13·42	1·76	1·10	12·74	0·44	0·44	—	4·55	34·58
8c	10% potash	69·15	15·62	3·06	0·67	11·28	0·22	—	—	4·44	33·74
8d	12½% potash	74·57	13·32	2·03	1·03	8·82	—	—	0·23	4·43	33·66

BASE.—7 lb. stable manure, ¼ lb. sulphate of potash per sq. yd. TOP.—(*a*) 2 oz. sulphate of potash per sq. yd. with first watering and 14 days later; (*b*) followed by 2 oz. per sq. yd. of a 7½ : 5 : 10 mixture until 7 days before stopping, (*c*) 7 days before stopping, 1 oz. dried blood per sq. yd., 14 days later 2 oz. dried blood per sq. yd. Afterwards top dressing mixture and dried blood alternately.

Table 5.

House No. 4. Series K. **Variety: Water Baby.**

Plot	Treatment during 1929.	Grade of Fruit: Percentage.								Total.	
		A.	B.	C.	D.	E.	F.	G.	H.	Lbs. per plant.	Tons per acre.
1b	Twice complete artificials (Formula I.)	75·20	19·26	1·32	2·11	1·32	0·26	0·53	—	3·79	28·80
1a	,, ,, ,, ,, with straw	78·00	17·86	0·48	1·71	1·71	—	0·24	—	4·09	31·08
2b	Unmanured	46·60	14·67	9·95	2·62	23·01	—	—	3·14	1·91	14·51
2a	Straw only	43·09	15·52	7·76	2·59	26·73	—	0·43	3·86	2·32	17·63
3b	Standard with complete artificials	76·67	18·97	0·77	2·05	0·77	0·51	0·26	—	3·90	29·64
3a	,, ,, ,, ,, and straw ...	79·65	17·27	0·48	1·68	0·92	—	—	—	4·16	31·61
4b	Complete artificials with dung	72·50	20·30	3·86	2·31	0·26	—	0·77	—	3·89	25·56
4a	,, ,, ,, and straw	76·48	17·42	3·29	1·17	1·17	—	0·47	—	4·25	32·30
5b	Complete artificials (Formula I.)	82·45	14·51	0·70	2·11	0·23	—	—	—	4·27	32·45
5a	,, ,, ,, and straw ...	87·25	10·22	0·23	1·61	0·23	—	0·46	—	4·35	33·06
6b	Complete artificials without phosphates	82·74	13·34	1·57	1·05	0·69	—	0·52	—	3·82	29·03
6a	,, ,, ,, ,, with straw	82·35	14·81	1·03	1·03	0·52	—	0·26	—	3·85	29·26
7b	Complete artificials without nitrogen	72·51	20·86	0·47	2·84	3·32	—	—	—	2·11	16·03
7a	,, ,, ,, ,, with straw ...	72·11	17·13	1·99	1·99	6·38	—	—	0·40	2·51	19·07
8b	Complete artificials without potash	36·86	11·83	2·63	0·88	45·61	0·44	—	1·75	2·28	17·32
8a	,, ,, ,, ,, with straw ...	44·07	10·42	5·86	2·18	35·53	0·97	—	0·97	3·07	23·33

The Director would like to acknowledge the assistance of Mr. B. D. Bolas in the preparation of Fig. 1.

The crop weights obtained from this series of experiments during 1929 are detailed below in Tables 4 and 5.

(b) Watering Experiments.

These experiments were a repetition of those arranged the previous year with certain modifications. Two plots, 4 and 7, were watered with a hose in the usual manner; two, 2 and 5, were similarly treated and the surface hoed regularly through the season, while in two others, 3 and 8, the water was applied by means of two inch drain pipes laid in rows some 15 inches below the surface.

In 1928 one line of pipes was allowed to each row of plants but this seemed excessive and, for 1929, alternate lines were removed. In the remaining plots, 1 and 6, the plants were set out in trenches 6 inches deep and sufficiently made to take a double row of plants. In 1928 the results were slightly in favour of planting in trenches and underground watering, but in the latter case there was evidence of waterlogging in the subsoil towards the middle of the season.

In the current experiments the heaviest crop was produced by underground watering, planting in trenches being a good second. The hoed plot gave a slightly higher yield than the control, but the result requires confirmation on a larger scale.

The growth in the underground watered plots was superior in every way to that in other plots up to the middle of June. Fruit set well and swelling was rapid. Later the foliage assumed a slightly yellow tint, and water proved to have accumulated in the subsoil. At this point underground watering was stopped in favour of the usual surface watering with a 1¼ inch hose. While the advantage of underground watering is definite, it is evident that this method can only be applied to certain types of soil. It uses almost double the usual amount of water and is therefore expensive. On the other hand, it requires considerably less labour. It would be useless in heavy soils where waterlogging would be rapid, and equally impossible to apply to very light soils unless the pipes were close to the surface where they would prevent proper cultivation. In moderately light soils, it may prove extremely useful, but is a method which requires careful handling.

The results of the current experiments are detailed in Table 6.

Table 6.

Methods of Watering. **Variety: E.S. 3.**

Plot No.	Treatment.	Grade of Fruit: Percentage.								Total lbs. per plant.	Total tons per acre.	Average total tons per acre.
		A.	B.	C.	D.	E.	F.	G.	H.			
1	Planted in trenches	66·5	4·2	21·5	1·3	4·3	0·5	1·4	0·3	4·63	35·19	34·70
6	,, ,, ...	73·2	4·4	12·5	1·7	6·1	0·3	1·4	0·4	4·50	34·20	
2	Watered through sunken pots...	73·4	4·8	17·2	0·9	3·3	0·3	0·1	—	4·49	34·12	32·41
5	,, ,, ,, ,, ...	79·7	5·5	9·0	1·3	2·9	0·3	1·0	0·3	4·04	30·70	
3	Underground watering	68·6	3·8	21·0	1·6	4·2	—	0·8	—	4·84	36·77	36·92
8	,, ,, ...	74·6	4·3	12·7	1·8	4·1	0·3	2·2	—	4·88	37·07	
4	Normal watering	73·7	7·0	11·4	1·6	3·8	0·9	1·6	—	4·16	31·60	31·75
7	,, ,, ...	75·9	5·6	10·9	2·1	3·4	—	1·5	0·6	4·20	31·90	

Table 7.

Variety Trials. House 5.

Variety.	Grade of Fruit : Percentage.								Total.	
	A.	B.	C.	D.	E.	F.	G.	H.	lbs. per plant.	tons per acre.
Manx Marvel ...	84·29	12·06	1·56	0·53	0·34	—	1·22	—	5·73	43·55
E.S. 1	83·76	12·28	2·26	1·52	—	—	0·18	—	5·29	40·20
Stonor's M.P. ...	88·76	8·34	2·14	0·58	—	—	0·18	—	5·16	39·22
Ailsa Craig ...	89·89	8·76	0·58	0·58	0·19	—	—	—	5·14	39·06
Walden Winner	78·91	16·94	2·57	0·99	0·59	—	—	—	5·07	38·53
Up-to-Date ...	33·12	8·55	49·14	3·63	2·36	0·42	2·78	—	4·68	35·57
Riverside ...	53·48	7·77	34·91	1·01	2·58	0·19	—	—	4·64	35·26
Buckley ...	46·39	4·15	45·09	0·66	2·42	0·20	1·09	—	4·57	34·73
Tuckswood ...	71·37	9·91	15·86	0·86	2·00	—	—	—	4·54	34·50
Stirling Castle	60·07	8·64	28·03	0·46	0·46	1·88	0·46	—	4·28	32·53
Satisfaction ...	28·26	5·99	53·25	0·49	7·27	3·75	0·99	—	4·00	30·40
Maincrop ...	28·64	7·62	52·14	2·45	6·42	2·45	0·28	—	3·28	24·93

(c) Variety Trials.

The results of these trials are shown in Table 7. Several new varieties were tested but none proved superior to the standard varieties. The F_2 generation of crosses between Up-to-date and Stirling Castle with E.S.1 were tested for resistance to leaf mould (*Cladosporium fulvum*) and cropping capacity. Unfortunately the attack of leaf mould was not severe in any of the experimental houses, and it was difficult to estimate the real degree of resistance.

As might be expected, the degree of resistance varied considerably with different individuals, and it was possible to select seed from plants showing marked resistance. The quality of the fruit was not satisfactory on any of the plants. A great many new crosses were made between Up-to-date and the standard commercial varieties for testing in 1930.

(d) Investigations concerning the reduction in yield of the tomato crop by continuous cultivation in the same soil.

In the past these experiments have suggested that the reduction in yield, which occurs when tomatoes are grown continuously in the same soil, is connected with some change in the physical condition of that part of the organic material known to nurserymen as "fibre." Thus the application of materials such as fresh grass cuttings and plain wheat straw have led to an increased crop. During the present season the experiments have been concerned mainly with the application of bean straw and wheat straw with and without stable manure. Crop results are provided in Table 8. By taking the average

Table 8.

Houses 7, 8, and 9. Series N, O, and P. **Variety: E.S. 1.**

House No.	Plot No.	Treatment during 1929.	Grade of Fruit: Percentage.								Total.	
			A.	B.	C.	D.	E.	F.	G.	H.	lbs. per plant.	tons per acre.
7	1	Straw, no stable manure	87·42	8·34	1·57	1·73	0·48	0·16	0·30	—	6·36	48·34
7	3	,, ,, ,, ...	88·37	8·68	0·56	1·65	0·19	0·19	0·36	—	5·41	41·12
7	7	Normal, with straw	87·66	8·79	1·35	1·69	0·33	—	0·18	—	5·91	44·92
8	3	,, ,, ...	85·91	8·44	1·07	2·14	1·37	—	1·07	—	6·52	49·54
9	7	,, ,, ...	84·06	9·65	2·52	2·05	0·72	0·57	0·43	—	6·74	51·22
8	2	Bean straw, no stable manure	85·24	9·51	1·36	1·87	0·67	0·17	1·18	—	5·90	44·84
9	6	,, ,, ,, ...	80·89	13·00	2·90	2·41	0·48	0·16	0·16	—	6·23	47·34
7	2	Normal, with bean straw	88·11	9·13	0·68	1·38	0·34	0·18	0·18	—	5·81	44·16
8	6	,, ,, ,, ...	81·38	10·79	0·49	2·78	1·14	0·32	3·10	—	6·12	46·51
9	2	,, ,, ,, ...	83·55	12·66	0·86	2·17	0·17	0·17	0·35	—	5·80	43·93
7	4a	Stable manure, with peat and lime ...	83·95	12·19	0·97	1·55	0·58	—	0·76	—	5·17	39·29
7	6	Normal	85·23	10·69	1·24	1·60	0·89	0·35	—	—	5·61	42·64
7	8	,, ...	83·96	10·18	2·79	1·70	0·47	0·30	0·60	—	6·49	49·33
8	7	,, ...	77·49	17·69	0·73	2·42	0·56	0·19	0·92	—	5·37	40·82
9	7	,, ...	84·06	9·65	2·52	2·05	0·72	0·57	0·43	—	6·74	51·22
7	5	Formaldehyde	79·40	15·36	1·02	2·69	1·02	0·51	—	—	5·92	44·99
8	4	,, and bulbs	77·71	13·51	1·18	3·20	1·69	0·18	2·53	—	5·92	44·99
9	4	,, ,, ...	82·63	13·61	1·25	2·19	—	—	0·32	—	6·39	48·56
8	5	Bulbs	78·71	11·35	0·69	2·80	2·43	0·53	3·49	—	5·73	43·55
9	5	,, ...	81·38	12·38	2·84	2·67	0·17	0·33	0·17	—	6·00	45·60
8	1	Soil heated to 80° F.	81·36	8·80	4·08	2·17	1·02	0·40	2·17	—	7·53	59·50
*8	8	,, ,, 75° F.	80·97	9·91	1·76	2·71	2·08	0·68	1·89	—	7·36	55·94
*9	1	,, ,, 70° F.	82·42	13·81	1·05	1·80	0·75	—	0·15	—	6·66	50·82
*9	8	,, ,, 65° F.	82·66	11·30	1·97	2·37	1·18	0·13	0·39	—	7·61	57·83

* A fault developed in the electric cable in these plots early in the season.

yield from the plots concerned it may be seen that a mixture of wheat straw and stable manure is more effective than stable manure alone, also that stable manure can be replaced for one year by either bean straw or wheat straw. The addition of bean straw to stable manure, however, did not increase the crop.

In the previous year the treatment of soil with formaldehyde followed by planting with tulips led to an increased tomato crop, and to determine if this increase was due to treatment with formaldehyde or the presence of decaying tulip roots, the experiment was extended in 1929. Three plots were sterilised with formaldehyde by diluting 1 gallon of the 40 % material with 49 gallons of water, applying the 50 gallons to 18 square yards, and forking over to a depth of 12 inches to facilitate mixing. Two of the plots were planted with tulips. Another plot was also planted with tulips without previous sterilisation. The tomato crop from all four plots did not vary appreciably from that of the controls, and the experiment will be repeated.

The experiments in House 10, Table 9, were designed to test the effect of different combinations of nitrogenous, phosphatic and potassic fertilisers. A combination of all three gave a yield of 35 tons per acre. Nitrogen and potash together also produced 35 tons per acre, while nitrogen and phosphate gave 32 tons, and potash and phosphate 35 tons per acre. The addition of grass cuttings to the complete mixture increased the yield to 41 tons per acre. The untreated controls produced an average of only 22 tons per acre.

Lime.

House 11, which received no lime in 1928, was treated similarly during the present season, while House 12 received caustic lime at the rate of 2 tons per acre during both seasons. In 1928 the crop in the unlimed house was 52·7 tons per acre as against 40·7 tons per acre in the limed house. A similar result was obtained in 1929; the unlimed house producing 46·2 tons and the limed 36·3 tons per acre. Both these houses were new in 1928 and the soil, on analysis, proved to contain only traces of carbonates. Such results require further investigation before definite advice can be given, but they suggest that useful information would be obtained if growers would arrange experiments on their own nurseries, to test the effect of withholding lime. It must be remembered, however, that dressings of lime are essential in the case of very heavy soils, for the purpose of improving their physical condition. Detailed results are provided in Table 10.

Table 9.

House 10. Series Q. **Variety: E.S. 1.**

Plot No.	Treatment during 1929.	Grade of Fruit: Percentage.								Total.	
		A.	B.	C.	D.	E.	F.	G.	H.	lbs. per plant.	tons per acre.
1a	Control	56·49	14·52	2·16	4·00	20·05	—	1·23	1·55	3·24	24·62
6a	,, ...	34·78	12·26	0·79	5·53	43·48	—	—	3·16	2·53	19·23
6b	Nitrogen, phosphates and potash	75·49	12·70	1·25	1·73	8·83	—	—	—	4·65	35·34
7b	,, ,, potash and straw ...	78·83	16·12	0·39	1·55	2·72	—	0·39	—	5·15	39·14
8b	,, ,, ,, ,, ...	72·30	18·31	0·94	1·64	5·40	—	1·17	0·24	4·26	32·38
1b	,, ,, ,, grass ...	80·78	12·69	0·19	1·31	4·66	—	0·37	—	5·36	40·74
2b	Phosphates and potash	67·99	13·74	2·83	1·74	12·84	—	0·44	0·22	4·59	34·88
2a	,, potash and straw	78·98	12·32	1·21	1·21	5·08	0·48	0·48	0·24	4·14	31·47
3a	Nitrogen and potash	78·31	10·22	1·43	1·79	8·25	—	—	—	5·58	42·41
8a	,, potash and straw	79·23	12·55	0·64	1·52	4·33	—	1·73	—	4·62	35·11
3b	Nitrogen and phosphates	61·12	12·39	2·63	2·59	20·80	—	0·24	0·24	4·24	32·21
7a	Grass only	49·04	14·40	1·56	2·33	29·18	—	1·58	1·96	2·57	19·53
4a	Virgin loam	82·91	11·41	1·26	2·37	1·85	—	—	0·20	5·51	41·88

Table 10.

Houses 11 and 12

House No.	Plot No.	Variety.	Treatment.			Crop Yield in Lbs. per Plant.						Tons per acre.
			Lime.	Stable Manure.	Top Dressing.	June.	July.	Aug.	Sept.	Oct.	Total.	
11	1	E.S.1	None ...	30 tons per acre...	2 oz. per sq. yd. ...	0·50	3·11	0·46	1·00	0·68	5·75	43·70
	4	E.S.1	,, ...	15 ,, ,, ...	1 ,, ,, ...	0·55	2·81	0·52	1·17	0·88	5·93	45·07
	2	E.S.2	,, ...	15 ,, ,, ...	2 ,, ,, ...	0·47	2·11	0·94	1·81	0·88	6·21	47·19
	3	E.S.2	,, ...	30 ,, ,, ...	1 ,, ,, ...	0·45	2·34	0·97	1·83	0·85	6·44	48·94
12	1	E.S.1	2 tons per acre	30 ,, ,, ...	2 ,, ,, ...	0·88	2·64	0·39	0·67	0·78	5·36	40·73
	3	E.S.1	2 ,, ,, ...	30 ,, ,, ...	1 ,, ,, ...	0·24	2·06	0·50	0·78	0·43	4·01	30·48
	2	E.S.1	2 ,, ,, ...	15 ,, ,, ...	2 ,, ,, ...	0·57	2·79	0·46	0·61	0·49	4·92	37·39
	4	E.S.1	2 ,, ,, ...	15 ,, ,, ...	1 ,, ,, ...	0·56	2·45	0·46	0·71	0·61	4·79	36·40

Stable manure.

Two plots in each house received stable manure at the rate of 30 tons per acre and two at the rate of 15 tons per acre, during both 1928 and 1929. In 1928 the average yields were 47 tons per acre where 30 tons of stable manure were applied and 46·7 tons in the case of 15 tons stable manure. During 1929, the yields were 40·9 tons and 41·5 tons respectively, thus confirming previous experiments which showed that 15 tons stable manure per acre is sufficient for the conditions prevailing in the experimental houses.

Top dressing.

Two plots in each house received top dressing at the rate of 2 ounces per square yard and two plots half that quantity. As in 1928, the result was slightly in favour of the heavier dressing which gave an average yield of 42·25 tons per acre as against 40·22 tons per acre.

2. Cucumber Experiments.

Previous results have shown that the chief cause of reduced cucumber crops is a contaminated condition of the base or ground upon which the beds are placed, and that this can be remedied by steam sterilisation. Experiment has also shown that a porous spongy bed provides the best conditions for the roots, and prolongs the life of the plant. The use of wheat straw in building up cucumber beds has been an improvement. An excellent crop has been grown in beds of straw and soil only, with an occasional light dressing of stable manure. The addition of plain straw to cucumber beds has been tested for six years, and the results suggest that this material should be used extensively by growers of this crop. In House C, two beds were made of stable manure and loam in the usual fashion, while in two, the stable manure was replaced by peat moss to which a little lime had been added. The peat plots received a dressing of dried blood, superphosphate and potash to compensate for the absence of stable manure. Injurious effects were noticed in the peat plots as early as June, and ultimately the plants became much inferior to those in the control plots. The peat plots averaged 73·8 tons per acre as against 82·7 tons per acre in the normal plots.

The results are definitely against the use of peat moss.

In Houses D and E the crops from an old bed sterilised, D5, and a new big bed, E3, both on a concrete base were compared with those from beds placed over soil which had been covered with concrete for seven years, D7 and E2. As in previous years the old bed sterilised produced as good a crop as a new big bed.

Table 11.

Variety: Butcher's Disease Resister.

Plot.	Treatment during 1929.	Pounds per Plant.								Total.	
		Mar.	April.	May.	June.	July.	Aug.	Sept.	Total.	Tons per acre.	Flats per ft.
C1	Normal bed	1·26	10·99	12·99	8·11	9·61	7·48	4·68	55·12	82·78	1·66
C3	,, ,, ...	0·88	8·20	14·19	8·77	9·38	8·64	5·03	55·09	82·63	1·66
C2	Soil and peat moss litter	0·44	10·42	13·51	7·35	8·28	7·41	5·59	53·00	79·50	1·60
C4	,, ,, ,, ...	0·74	9·44	10·78	7·59	7·49	5·73	3·70	45·47	68·20	1·37
D2	Normal bed	1·95	10·99	12·14	10·73	9·05	7·34	4·35	56·55	84·82	1·71
D3	Bed with ashes and hedge clippings	1·06	9·93	14·47	8·61	8·58	8·06	2·32	53·03	79·55	1·60
D5	Old bed steamed	1·06	10·74	12·32	9·77	8·82	7·65	3·55	53·91	80·86	1·63
D6	Concrete removed : no additional base treatment	2·17	9·09	10·94	9·73	8·60	7·77	4·23	52·53	78·79	1·58
E2	,, ,, ,, ,, ,,	1·46	10·79	13·10	10·35	11·56	10·40	4·14	61·80	92·70	1·86
E3	New big bed	1·54	9·92	12·31	8·28	10·72	8·15	3·79	54·71	82·06	1·65
E4	Control	1·65	8·29	10·56	9·29	9·09	6·73	2·51	48·12	72·18	1·45
F1	Normal bed	2·43	12·24	13·41	10·69	10·28	9·35	5·06	63·46	95·19	1·91
F2	,, ,, ...	1·98	11·90	13·50	9·73	10·14	7·86	4·92	60·03	90·04	1·81
F3	Bed with ashes and bean straw	1·23	10·48	12·98	10·13	10·24	8·58	3·01	56·65	84·97	1·71
F4	Steamed old bed with ashes and bean straw ...	2·31	12·63	16·52	12·50	11·90	10·61	4·43	70·90	106·35	2·14
F5	Steamed old bed	2·65	13·66	16·88	11·89	11·41	10·86	6·34	73·69	110·53	2·22
F6	,, ,, ...	3·53	14·41	15·47	12·51	10·10	10·47	6·60	72·09	108·14	2·18

The yields from the beds placed over ground previously covered with concrete during seven years showed a considerable difference between the two, and it is interesting to compare them with those obtained before the bases were concreted.

In 1921, the crop from D6 was 55 tons per acre, and from E2 70 tons per acre. After seven years' rest D6 gave 79 tons per acre and E2 93 tons per acre. The control bed, in which the base has been untreated except for digging and liming, since 1916 produced 72 tons per acre.

Such results suggest that, while the base conditions were improved during the seven years it was covered by concrete, the injurious influences still remain in much the same proportions. The addition of hedge clippings and ashes, D3, and also bean straw, F3 and F4, did not improve the crop during 1929. Bean straw tends to become slimy on decomposition and is hardly suitable for cucumber beds.

In House F, Plots 1, 2, and 3 were new beds over a steamed base, while in 4, 5, and 6 the old beds were spread and then steamed. The average crop from the former three plots was 90 tons per acre and from the old beds steamed 108·5 tons per acre. This confirms previous results.

Detailed results are given in Table 11.

3. Soil Sterilisation.

Through the kindness of Mr. E. S. Shoults, it is possible to give the results of certain experiments with formaldehyde which he conducted during the past year.

The eight houses used for the experiment, were first cropped in 1923 and had always proved unsatisfactory, the ground being heavily infested with wireworms, and many plants dying each year from various fungal root diseases.

Grass was sown in November in Houses 73 and 75, but did not make much growth until February when it was dug in, as the vapours of formaldehyde from neighbouring houses checked its development considerably. In House 72, a 2% solution of formaldehyde (1 gallon 40% formaldehyde in 49 gallons of water) was applied to the soil at the rate of 6·7 gallons per square yard, previous tests having shown that this quantity of liquid is necessary to saturate the top twelve inches of soil. In House 74, a 2% solution was used at only 3·3 gallons per square yard, while House 76 received 6·7 gallons per square yard of an 0·66% solution. The ground was then covered with canvas for 24 hours.

One gallon cresylic acid in about 100 gallons water was applied to each 15 square yards of soil in House 71.

The above treatments were applied by means of an injector during the first fortnight of December, 1928, planting taking place in March 12th, 1929.

Table 12.

House. No.	Variety.	Treatment.	Crop in tons per acre.
69	Buckley	Control	32·0
70	Pale Blako	Control	31·0
71	,,	Cresylic acid	40·2
72	Ailsa Craig × Blaby	* 2% solution formaldehyde; 6·7 gallons per square yard	50·2
73	,,	Grass	43·3
74	,,	2% solution formaldehyde: 3·35 gallons per square yard	46·5
75	,,	Grass	36·0
76	,,	0·66% solution formaldehyde: 6·7 gallons per square yard	39·0

* A 2% solution was prepared by adding 1 gallon 40% formaldehyde to 49 gallons water.

The results in the above table indicate that the weight of crop increased in accordance with the amount of formaldehyde applied, a crop of 50 tons per acre resulting from the application of 1 gallon 40% formaldehyde in 49 gallons of water to $7\frac{1}{2}$ square yards. This is a little more than twice the usual rate, and suggests that further trials are necessary.

The order of the crops were as follows:—

Formaldehyde	Full dressing	50·2	tons per acre
,,	Half dressing	46·5	,,
,,	One-third dressing	39·0	,,
Cresylic acid	—	40·2	,,
Grass	—	39·1	,,
Control	—	31·5	,,

The poor crop in the control houses was caused by plants dying after the third or fourth trusses were picked. In the grass and cresylic acid treated houses the number of dead plants was inconsiderable, while but few plants died in the houses treated with formaldehyde.

2. Mycological Investigations.

The following diseases not previously reported have been recorded during the year:—

Host.	Disease.	Cause.
Asparagus plumosus ...	Root rot	*Fusarium sp.*
Aster	"Damping-off" ...	*Phytophthora cryptogea*
Carrot	Dry rot	*Fusarium sp.*
Gladiolus	Root rot	*Fusarium sp.*
Iris	Internal rot	Frost injury
Narcissus	Bulb rot	*Fusarium sp.*
Pelargonium	Foot rot of cuttings ...	*Fusarium sp.*
Pink	Wilt	*Fusarium sp.*
Quince	Leaf Spot	*Fabræa maculata*
Tobacco	Crown Gall	*B. tumefaciens*
Tulip	"Fire"	*Botrytis tulipæ*
,, ...	Bulb rot	*Fusarium sp.*
Viola	Leaf spot	*Phyllosticta violæ*
Chrysanthemum... ...	Wilt	*Verticillium sp.*

1. An investigation of the micro-flora of certain tomato soils.

By P. H. Williams.

Tomato House 4 (Series K) has been devoted to manurial trials since 1915, and the present treatments of the different plots have remained constant since 1917. Before terminating the experiments at the end of 1929, it was decided to examine the bacterial and fungal population of selected plots, which had been treated as follows:—

Plot 2b—No manure.
,, 4b—Complete artificials + stable manure.
,, 5b—Complete artificials.
,, 6b—Complete artificials less Phosphates.
,, 7b—Complete artificials less Nitrogen.
,, 8b—Complete artificials less Potash.

The numbers of bacteria, actinomyces and fungi were counted at fortnightly intervals from January 29th to May 28th and subsequently at longer intervals until November 12th. Samples were taken of the top 6 inches of soil and were plated by the methods employed at Rothamsted Experimental Station.

The results are given in Tables 1 to 3.

Numbers of Bacteria.

The numbers of bacteria in millions per gramme of dry soil are shown in Table 1, and for Plots 2, 4, and 5 in Fig. 1.

Table 1.

Number of bacteria in millions per gramme of oven dry soil.

Date.	PLOT.					
	2.	4.	5.	6.	7.	8.
29/1/29	13·29	32·68	20·50	31·25	42·04	38·41
12/2/29	13·55	55·69	55·64	48·83	37·57	45·95
19/2/29	16·31	30·59	36·21	34·81	36·68	37·41
5/3/29	16·59	50·63	44·65	35·37	55·93	34·53
19/3/29	11·50	78·20	30·27	28·49	33·78	25·25
3/4/29	13·32	52·08	21·74	15·81	29·35	15·93
16/4/29	13·60	42·13	24·65	20·20	22·36	23·80
30/4/29	14·85	49·87	26·89	24·63	28·13	24·77
14/5/29	18·75	20·60	20·50	18·61	15·84	10·15
28/5/29	16·50	30·85	17·42	15·48	18·99	16·13
25/6/29	30·31	33·21	34·51	27·79	49·58	43·88
16/7/29	20·12	15·08	16·95	20·00	23·54	24·12
7/8/29	20·44	19·98	17·92	17·76	21·22	17·41
19/9/29	16·51	24·97	13·06	13·03	10·16	14·15
8/10/29	31·89	30·06	19·60	19·72	27·65	35·30
29/10/29	24·44	16·34	17·34	19·54	26·89	18·23
12/11/29	35·08	19·93	14·56	14·02	26·19	16·50

In Plot 2 (unmanured) the bacteria remained at a comparatively low level throughout the early part of the season. A maximum in the last fortnight of February would seem to correspond to that found in other plots about March 5th. The largest numbers were recorded in June.

Plot 4 (complete artificials with stable manure) shows clearly the effect of stable manure. The numbers rose rapidly and remained considerably higher than in the other plots for over two months.

In the remaining plots the numbers show a tendency to rise or fall at about the same period. Records have been made of the soil moisture at the time of sampling and of the daily soil and air temperatures, but it seems impossible to correlate the variations in bacterial numbers with any of these factors.

An interesting point noted was that, contrary to expectation, the rise in soil temperature following the commencement of heating was accompanied by a fall in the numbers of bacteria. It seems desirable to investigate this matter more fully in the coming year.

The first top dressing and watering was given on May 1st. This was followed by a decrease in the numbers of bacteria in all plots except number 2. In Plot 4, it is very apparent and marks the end of the relatively high numbers which had distinguished this plot from the remainder. In this connection attention may be drawn to the decrease in soil nitrates which occurs at this period.

Numbers of Actinomyces.

The numbers of Actinomyces are given in Table 2.

Table 2.

Numbers of Actinomyces in millions per gramme of oven dry soil.

Date.	PLOT.					
	2.	4.	5.	6.	7.	8.
12/2/29	0·83	0·75	0·30	0·96	0·54	0·67
19/2/29	1·68	3·03	1·27	1·31	0·92	0·79
5/3/29	1·99	2·90	0·53	2·41	0·65	1·19
19/3/29	1·31	2·40	1·42	1·24	0·81	1·63
3/4/29	1·65	2·83	1·12	1·64	0·65	1·30
16/4/29	1·46	3·58	0·92	1·30	0·88	0·91
30/4/29	1·71	2·68	1·17	1·64	0·51	1·90
14/5/29	1·64	2·13	1·31	1·91	1·12	1·41
28/5/29	2·13	4·26	1·29	1·66	1·18	1·37
25/6/29	7·15	4·46	2·55	2·29	2·25	3·11
16/7/29	1·70	2·43	1·41	0·89	1·29	1·66
7/8/29	1·44	3·61	1·18	1·76	1·92	1·11
19/9/29	2·08	4·43	1·43	2·06	0·80	2·34
8/10/29	2·93	3·45	2·27	2·07	2·29	2·67
29/10/29	1·53	2·84	1·92	1·39	1·44	1·19
12/11/29	1·45	1·89	1·79	1·67	1·13	0·93

In the early part of the season the numbers tended to vary inversely to those of the bacteria. In Plot 2 there was, however, a general agreement throughout the season. Later in the year the numbers of actinomyces correspond more closely with those of the bacteria. The maximum numbers were recorded in June.

The numbers rose to a maximum on April 30th except in Plot 8 where the highest value was recorded on May 14th. Plots 4 and 7 show uniformly the highest numbers. No material effect on the numbers was produced by the addition of stable manure.

A number of fungi were isolated, the majority of which were species of *Penicillium*. *Trichoderma koningi* occurred in a large number of plates and was probably the most abundant species in the soil examined. *Fusarium culmorum* was the only known pathogen encountered.

Numbers of Fungi.

The results of counts of the fungi are given in Table 3.

Table 3.

Numbers of Fungi in thousands per gramme of oven dry soil.

Date.	PLOT.					
	2.	4.	5.	6.	7.	8.
19/2/29	172·00	167·00	103·60	68·19	207·30	94·12
5/3/29	93·15	145·10	62·46	73·57	61·80	59·73
19/3/29	119·60	147·40	58·33	62·40	115·90	52·49
3/4/29	141·50	205·10	85·43	84·29	237·20	73·53
16/4/29	128·90	211·00	76·02	75·50	141·60	87·32
30/4/29	252·20	409·70	111·50	122·30	381·70	132·90
14/5/29	111·70	290·50	157·30	—	—	—
25/6/29	47·08	33·21	26·73	14·69	42·58	28·99
16/7/29	36·59	16·32	20·31	16·11	29·81	19·63
7/8/29	130·50	51·76	43·89	47·06	68·06	43·68
19/9/29	99·97	93·93	56·06	55·30	62·10	43·84
8/10/29	133·80	62·22	79·91	66·15	66·82	51·98
29/10/29	58·60	53·31	52·78	59·02	40·52	53·13
12/11/29	47·17	126·50	50·43	60·06	58·34	35·56

Soil moisture.

The percentage of moisture in the soil was determined at the time of each sampling. The results are shown in Fig. 2. Plot 4 shows the highest values at the commencement of the season, while Plot 2 is the lowest. It will be noted that, towards the end of the year, Plots 2, 7 and 8 gradually rose to a higher level than the remainder. This is no doubt to be correlated with the poor growth made by the plants in these plots, resulting in the absorption of less water than in other plots.

Summary.

(1) The numbers of bacteria, actinomyces and fungi in certain tomato soils have been determined.

(2) No correlation was found between the variations in the numbers of micro-organisms and either soil moisture or soil temperature.

(3) Bacterial numbers were greatly increased by the addition of stable manure to the soil. Actinomyces and fungi were not so affected.

(4) The first heavy watering of the season was followed by a fall in bacterial numbers.

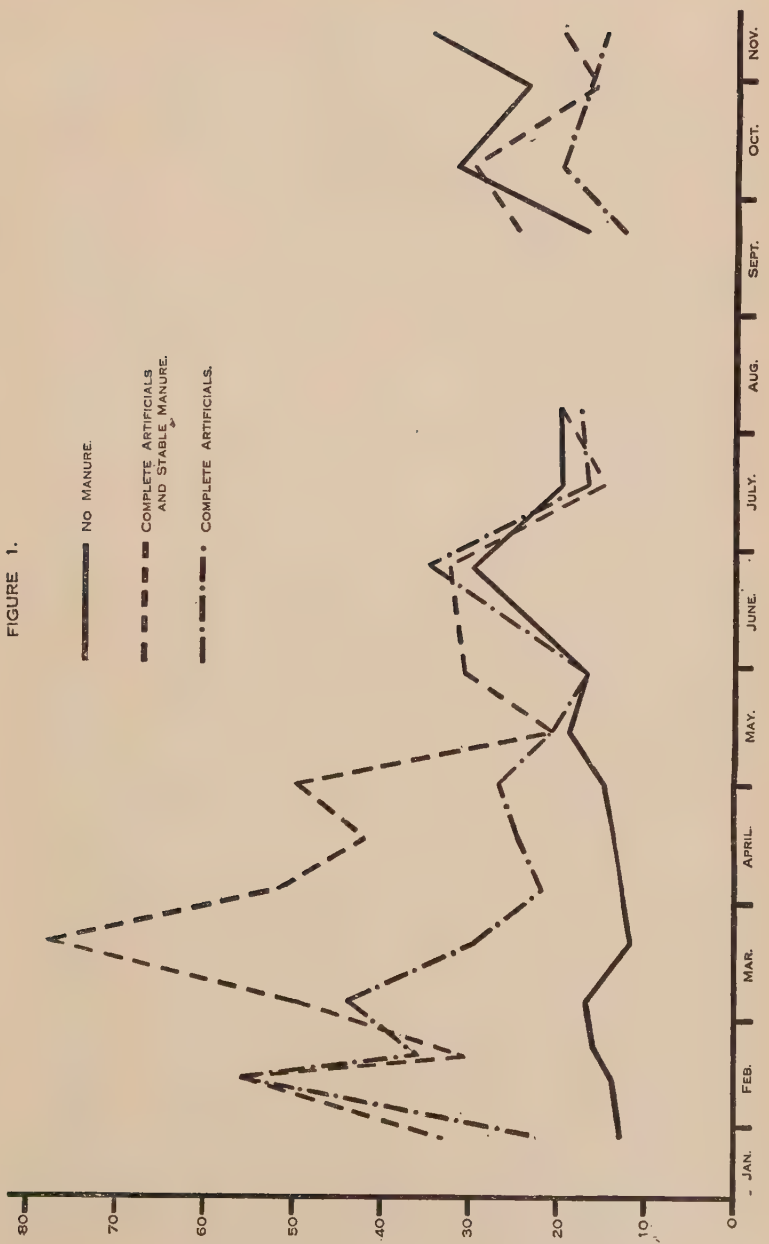


FIGURE 1.
No Manure.
Complete Artificials and Stable Manure.
Complete Artificials.
Bacterial Numbers. Millions per Gramme of Dry Soil.
0
10
20
30
40
50
60
70
80
Jan.
Feb.
Mar.
April.
May.
June.
July.
Aug.
Sept.
Oct.
Nov.

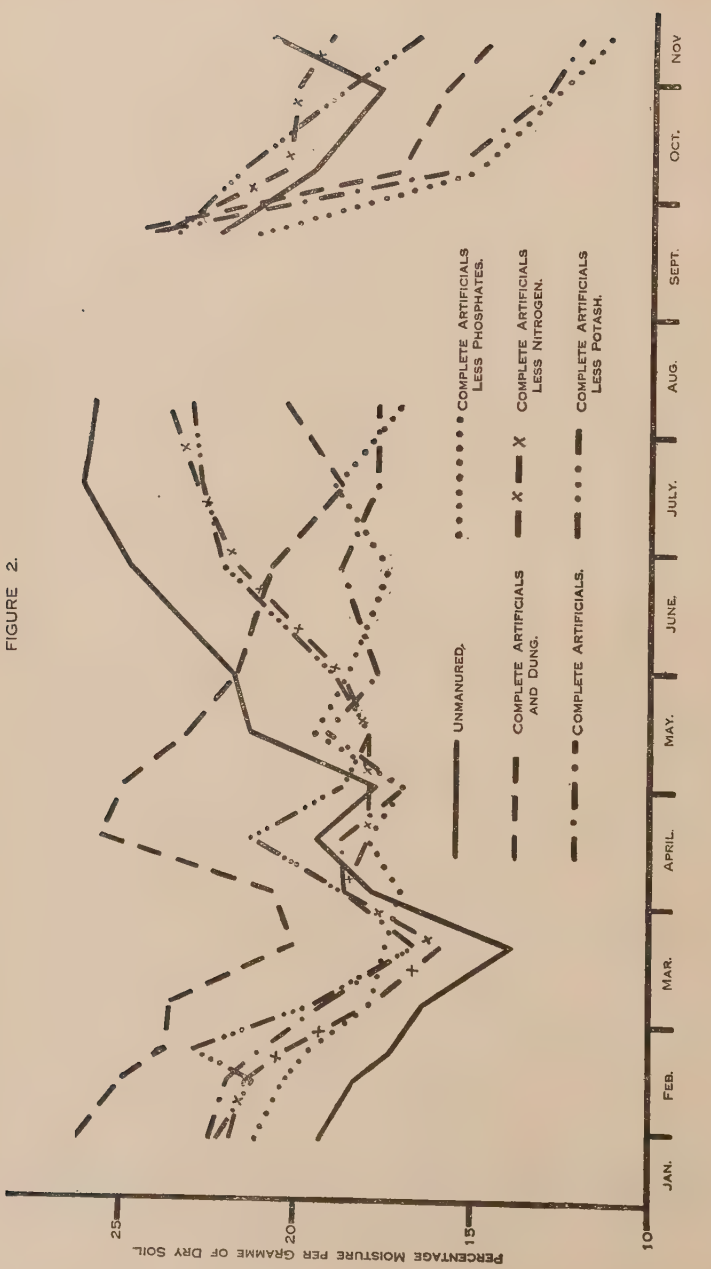

PERCENTAGE MOISTURE PER GRAMME OF DRY SOIL.
25
20
15
10
JAN.
FEB.
MAR.
APRIL.
MAY.
JUNE.
JULY.
AUG.
SEPT.
OCT.
NOV
UNMANURED.
COMPLETE ARTIFICIALS AND DUNG.
COMPLETE ARTIFICIALS.
COMPLETE ARTIFICIALS LESS PHOSPHATES.
COMPLETE ARTIFICIALS LESS NITROGEN.
COMPLETE ARTIFICIALS LESS POTASH.

FIGURE 2.

2. Tomato Leaf Mould.

By T. Small.

Relation of leaf mould to environmental conditions.

This relation was studied last year in experiments made under controlled conditions (see Fourteenth Annual Report). The next step was to determine to what extent conditions favourable to leaf mould occurred in commercial nurseries, and the means whereby these conditions could be avoided or improved.

By the kindness of Mr. J. C. Cobley, Mr. C. H. Shoults, and Mr. E. S. Shoults, most of the work was carried out on their nurseries. By means of thermo-hygrographs, placed among the plants, continuous temperature and humidity records were taken from April to September in houses where leaf mould is usually severe. The instruments were standardised each week. The nurseries were inspected frequently and notes taken concerning the appearance and development of leaf mould, ventilation, watering, heating, etc. Further information was obtained by occasional visits to other nurseries.

Data calculated from the temperature and humidity records mentioned above are summarised in Tables 1 and 2.

The data show that considerable daily and weekly fluctuations of temperature and humidity occurred regularly. At night, the temperature fell, reaching a minimum (weekly average 50°F.–60°F.) between 4 a.m. and 6 a.m., while the humidity rose, reaching a maximum (weekly average 90-95%) which persisted for several hours. During the day, the temperature rose, reaching a maximum (weekly average 70°F.-80°F.) in the afternoon, while the humidity fell to a minimum which was usually between 50 and 70%. During sunny periods, day temperatures reached 85°F.-92°F., and the humidity fell to about 45%; the night humidity usually rose above 90%.

When such daily fluctuations of temperature and humidity occur optimum conditions for leaf mould (a high humidity coincident with a temperature about 72°F.) do not obtain and the disease is unlikely to become severe.

In rainy or cloudy weather, however, daily fluctuations of humidity are less marked, the humidity remaining high both night and day. Cases have been recorded where the humidity exceeded 85% for four consecutive days. Under such conditions epidemics of leaf mould are liable to develop unless unusually low temperatures occur. The almost complete absence of warm, rainy periods during the past season, probably explains why leaf mould appeared later than usual and was far less severe; the attack was the mildest recorded by many experienced growers.

Table 1.

Table showing weekly average temperature and weekly average maximum (day) and minimum (night) temperature (°F.) in three commercial nurseries (1929).

No. of Wks.	Date.	NURSERY 1.						NURSERY 2.			NURSERY 3.			Weather Conditions.
		Position A.			Position B.									
		Av.	Av. Max.	Av. Min.	Av.	Av. Max.	Av. Min.	Av.	Av. Max.	Av. Min.	Av.	Av. Max.	Av. Min.	
1	2–8.4	60	79	50	60	79	51	—	—	—	—	—	—	
2	8–15.4	61	73	56	61	73	56	—	—	—	—	—	—	Sunny days, cold nights
3	15–22.4	65	81	57	66	79	56	62	74	54	71	84	59	
4	22–29.4	62	74	55	62	72	57	—	—	55	—	—	—	
5	29.4–6.5	60	70	53	62	71	56	56	66	50	—	—	—	
6	6–13.5	62	70	56	62	69	57	62	71	57	—	—	—	
7	13–20.5	62	76	55	61	71	55	63	74	56	67	84	59	
8	21–27.5	68	83	58	68	83	61	71	85	61	71	86	64	Fine and sunny
9	27.5–3.6	64	80	56	64	78	55	63	79	55	67	82	60	
10	3–10.6	61	70	54	61	67	55	63	73	55	65	78	59	
11	10–17.6	62	74	54	63	73	57	65	78	58	—	—	—	
12	17–24.6	64	80	54	64	75	56	—	—	56	68	82	60	
13	24.6–1.7	60	72	49	61	73	53	64	78	56	63	74	54	
14	1–8.7	61	70	52	61	71	54	65	79	57	63	72	56	
15	8–15.7	67	78	51	67	81	54	70	88	58	71	89	58	8-19.7 fine & very sunny
16	15–22.7	68	—	—	70	—	—	74	92	61	71	86	58	20.7 drought broken
17	22–29.7	63	—	—	63	—	—	—	—	—	62	73	54	
18	29.7–5.8	60	70	53	62	68	54	—	—	—	62	70	54	
19	6–13.8	62	75	54	62	72	56	—	—	62	70	76	56	
20	13–19.8	60	73	53	60	70	53	—	—	58	—	—	—	
21	19–26.8	65	82	54	65	74	54	—	—	58	—	—	—	
22	26.8–2.9	66	82	55	66	84	55	69	85	60	69	78	62	
23	2–9.9	68	87	56	68	85	57	73	88	62	—	—	—	Fine and sunny period
24	9–16.9	65	80	54	65	79	56	69	84	60	—	—	—	
25	16–23.9	60	71	53	60	71	53	64	74	57	61	71	54	
26	23–30.9	58	76	46	58	74	47	—	—	54	58	72	50	First rain for several weeks on 29.9

Table 2.

Table showing weekly average relative humidity and weekly average maximum (night) and minimum (day) relative humidity in three commercial nurseries (1929).

No. of Wks.	Date.	NURSERY 1.						NURSERY 2.			NURSERY 3.		
		Position A.			Position B.								
		Av.	Av.Max.	Av. Min.	Av.	Av.Max.	Av. Min.	Av.	Av.Max.	Av. Min.	Av.	Av.Max.	Av. Min.
1	2–8.4	70	79	52	80	87	65	—	—	—	—	—	—
2	8–15.4	73	86	67	86	91	75	—	—	—	—	—	—
3	15–22.4	82	95	59	87	95	75	88	96	62	75	92	57
4	22–29.4	81	90	69	92	—	79	86	96	80	—	—	—
5	29.4–6.5	86	96	71	90	96	79	93	98	80	—	—	—
6	6–13.5	80	90	66	89	98	71	87	95	72	—	—	—
7	13–20.5	81	90	69	85	96	69	86	96	69	86	97	65
8	21–27.5	78	97	48	85	98	65	84	93	64	77	95	53
9	27.5–3.6	77	93	64	82	92	68	87	95	73	87	96	64
10	3–10.6	86	94	69	84	92	73	87	95	70	88	97	67
11	10–17.6	79	97	60	82	93	69	84	95	65	—	—	—
12	17–24.6	73	91	63	83	97	53	79	93	62	80	95	50
13	24.6–1.7	—	88	56	73	87	63	80	93	65	80	94	63
14	1–8.7	78	91	61	83	91	70	80	91	72	82	92	65
15	8–15.7	70	91	49	81	96	60	73	93	49	70	93	42
16	15–22.7	—	—	—	—	—	—	—	93	49	78	95	54
17	22–29.7	—	—	—	—	—	—	—	—	—	82	—	63
18	29.7–5.8	86	97	69	89	92	84	—	—	—	81	95	71
19	6–13.8	84	96	62	90	95	81	83	93	65	79	91	57
20	13–19.8	79	95	58	89	98	74	79	94	54	—	—	—
21	19–26.8	78	91	52	89	97	73	82	95	63	80	93	64
22	26.8–2.9	83	98	57	75	92	47	82	96	57	—	—	—
23	2–9.9	84	97	53	83	92	59	83	95	56	—	—	—
24	9–16.9	82	—	—	81	—	—	83	—	—	—	—	—
25	16–23.9	80	—	—	87	—	—	81	—	—	81	—	—
26	23–30.9	79	—	—	86	—	—	—	—	—	82	—	—

With regard to ventilation and watering, these varied so much in different nurseries that it was difficult to estimate their effect on leaf mould. On one nursery, night-ventilation was given in April; in others none was given until July, while in one case it was withheld throughout the season. Concerning soil watering, it was evident that, even allowing for soil differences, some tomato crops received far more water than others. When overhead damping was conducted on fine days, the plants dried in a few hours; if done late afternoon or on rainy days the plants remained wet (*i.e.*, in an ideal condition for infection) for several hours.

It was clear from observations that inadequate ventilation and excessive watering produced a forced type of growth. As a rule, forced crops suffered most from leaf mould during the past season. On one nursery the entire crop, which had been deliberately forced, was practically dead in August. In Nursery No. 2 (see Table 1) crops in the latest planted and coolest houses suffered least from leaf mould; in the forced houses the disease appeared about five weeks after planting and spread rapidly during May and June. In July full ventilation was given continuously, and the attack became less severe.

An interesting case arose in Nursery No. 1, where plants in position B. became diseased, while others in another part of the same house, *i.e.*, position A., remained healthy. The former plants grew quicker and were softer. Environmental conditions were apparently alike in the two positions except that a higher day humidity occurred regularly in position B. (see Tables 1 and 2).

In Nursery No. 3 the plants were small-leaved and rather hard, possibly owing to the limited water supply. The crop remained practically healthy except in one house. In this house, which contained the tallest and softest plants in the nursery, leaf mould was severe in June, up to which time no night ventilation had been given. Early in July all available ventilators were left fully open continuously, and the crop was severely pruned. The disease became less severe although it persisted throughout the season.

The above records and observations together with previous work suggest that attacks of leaf mould originate at night or early morning in fine weather, and during the day or night in cloudy or wet weather. The problem is to reduce the humidity during these periods. The means at present available to the grower are ventilation, pipe heat, particular attention to watering and drastic pruning. From the data so far available it appears questionable if conditions can be sufficiently improved by the above means. It is hoped to obtain further information on this important point during 1930.

Fungicides.

Experiments are in progress to test the effect of fungicides on leaf mould.

To determine the protective action, plants eight inches high were sprayed with the fungicide, and when dry they were lightly sprayed with a suspension of spores in water, placed in a moist chamber for two days and subsequently grown in a glasshouse. To test the direct toxic action (curative action) of fungicides germination tests were carried out, using spores from diseased plants which had been sprayed with the fungicide on the previous day. Saponin (0·02%) was added to the fungicides and suitable controls were employed.

It should be pointed out, perhaps, that the protective action of fungicides is more important than the curative action in diseases such as leaf mould, where so much of the fungus is inside the plant. In the latter case the fungus grows through the original diseased spots four to five days after spraying, so that frequent applications are necessary. Nevertheless the method may be practicable and useful in checking the spread of leaf mould when early or local attacks occur.

The results showed that both the protective and the curative actions were inefficient in the case of cheshunt compound (0·5%), liver of sulphur (0·5 and 0·25%), ammonium polysulphide (0·5%), and sodium polysulphide (1·0 and 0·5%). A 1% solution of ammonium polysulphide showed both protective and curative action. The work is being continued.

It may be noted here that inoculation experiments have shown that infection may occur on either surface of the leaf, and that in either case leaf mould usually develops on the lower surface only. It is not known whether, under natural conditions, infection occurs on one or on both leaf surfaces; until this is known it is advisable to apply fungicides to both leaf surfaces.

Sulphur vapour.

In these experiments 0·25 lb. of flowers of sulphur was vapourised by Campbell's Patent Sulphur Vapouriser in a glasshouse (capacity 635 cubic feet and temperature 70°F.-80°F.) containing diseased plants and leaves in normal and reversed positions, and glass slides dusted with spores on the upper and lower surfaces. Using spores from these preparations, germination tests were made the day after fumigation. Suitable controls were used.

The results showed that frequently most of the spores remained alive, but occasionally almost all of them were killed. The experiments are being continued.

Mode of infection.

Stomatal infection has been frequently observed during this investigation. To determine if infection could occur in darkness, inoculated plants were placed in darkness in a moist chamber at 72°F. for seven days and were afterwards grown in a glasshouse. Controls were treated similarly except that they were always grown in the light during the day.

Leaf mould appeared on both treated and control plants five days after their removal to the glasshouse; this indicated that infection occurred in darkness. Provided that the stomata were closed continuously when the plants were in darkness, the result suggests that either the germ tubes force their way through closed stomata, or infection is not exclusively stomatal. From the practical point of view the result is interesting, because it suggests that infection may occur during the night.

Open tank experiment.

Six plants were inoculated and, when dry, were placed in an open, dry glass tank, their tops being about six inches below the top of the tank. These plants developed far more leaf mould than inoculated plants placed outside the tank.

The result clearly showed that plants under certain environmental conditions may suffer severely from leaf mould, while others under but slightly different conditions remain almost healthy.

Inoculation of flower trusses.

The plants used in this experiment were stopped at the second truss; as the first and second trusses developed the flowers were removed except the five basal ones, which were sprayed with water (controls) or were inoculated with dry spores and with a suspension of spores in water. After each inoculation, the plants were placed in a moist chamber for three days and were subsequently grown in a glasshouse.

Control plants (four) produced thirty-one fruits, all of which were healthy; inoculated plants (four) produced only six fruits and these were diseased at the stem end and each possessed a shrivelled, infected calyx. The disease had not penetrated far into the ripe fruits; isolations from inside the fruits yielded *C. fulvum*.

The results indicate that blossom infection may cause serious reduction in crop yield. This loss is aggravated by the reduced market value of fruit through infection and consequent browning of the calyx.

It is worth noting that inoculation of detached green and ripe fruits by spore suspensions, diseased leaf tissue, or by pure cultures failed to establish infection.

Leaf mould on outdoor crops.

Four large plants grown outdoors were inoculated at weekly intervals from 18th June, 1929, to 30th July, 1929; on the 30th July, 1929, all the plants were healthy, but on 16th August, 1929, they were diseased. Controls remained healthy.

The experiment showed that, under certain conditions, leaf mould may attack outdoor crops. Early in September a diseased outdoor crop was observed in South Devon.

Leaf mould on manured and starved plants.

Large plants in pots were used in this experiment; one series received a base dressing of stable manure, bone meal and bone flour, and frequent top dressings of a quick acting nitrogenous manure; a second series, unmanured, was grown in virgin soil. When inoculated the third truss was present; the manured plants were soft and dark green, while the starved plants were hard and light green.

Leaf mould developed far more severely on the manured plants; on starved plants it was most evident on the younger foliage, but the diseased spots remained small, and comparatively little sporulation occurred.

Leaf mould on leaves of various ages.

Leaves below the first truss and above the second were inoculated; the plants were placed in a moist chamber for three days and subsequently grown in a glasshouse.

Leaf mould developed equally on both sets of leaves. Thus, under the experimental conditions, leaves of various ages were equally susceptible to leaf mould.

Cross inoculations.

Plants belonging to various families were inoculated with *C. fulvum*, but in no case was infection established although, it is interesting to note, the spores usually germinated.

So far as is known *C. fulvum* attacks tomato plants only.

Overwintering.

The spores of *C. fulvum* can overwinter on diseased leaves (Fourteenth Annual Report).

To determine if they could overwinter on the glass and woodwork of houses and in the soil, they were kept in an open glasshouse during the severe winter of 1928-9, (*a*) in plugged glass tubes, (*b*) on wood, (*c*) in dry, sterile and non-sterile soil, in open and closed dishes. In spring, inoculation of plants with spore suspensions made from these preparations caused leaf mould to appear. Controls remained healthy. The experiment shows that spores can overwinter on glasshouse structures and in the soil.

Cleaning of glasshouses before planting.

It was shown last year that cresylic acid emulsion is toxic to spores of *C. fulvum*.

The toxicity of burning sulphur was tested in experiments carried out in a glasshouse (capacity 635 cubic feet) containing diseased plants and leaves, and glass slides dusted with spores. Germination trials were made the day after fumigation.

One pound of sulphur in one heap failed to kill many of the spores, whereas four heaps, each of 0·25 lb., burned simultaneously, killed practically all the spores. Quantities of sulphur less than one pound were less satisfactory.

In some of the experiments, the temperature of the glasshouse was 70°F.-80°F., while in others it was 54°F.-60°F.; the results were similar at both these temperatures.

Flooding the glasshouse before fumigation did not influence the results.

Thus, both cresylic acid and burning sulphur are toxic to spores of *C. fulvum*; either substance may be of use for cleaning glasshouses before planting.

The experiments are being continued.

Summary.

(1) During the past season, the relation of leaf mould to environmental conditions has been studied on commercial nurseries. Data are given which show that considerable daily fluctuations of temperature and humidity occurred regularly except in rainy or cloudy weather. When such fluctuations occur optimum conditions for leaf mould do not obtain and the disease is unlikely to become severe. In rainy or cloudy weather, however, the humidity remains high both day and night, and epidemics of leaf mould are liable to develop unless unusually low temperatures occur.

(2) Leaf mould was far less severe than usual during the past season. As a rule forced crops suffered greatest; such crops are produced largely by inadequate ventilation and excessive watering.

(3) It is suggested that attacks of leaf mould originate at night or early morning in fine weather, and during the night or day in cloudy or wet weather. The chief problem is to reduce the humidity during these periods.

(4) Experiments are in progress to test the effect of fungicides on leaf mould. In small-scale experiments the disease was controlled by ammonium polysulphide, but further trials are necessary before recommendations can be made.

(5) Inoculation experiments have shown that infection may occur in darkness; that plants under certain environmental conditions may suffer from leaf mould, while others under but slightly different conditions remain almost healthy; that *C. fulvum* may attack flower trusses and cause serious reduction in crop yield; that the disease may attack outdoor crops; that well-manured plants are more susceptible than starved ones; and that leaves of different ages are equally susceptible to attack.

(6) Inoculation of various plants, other than the tomato, failed to establish infection.

(7) The spores of *C. fulvum* can overwinter on diseased leaves, glasshouse structures and in the soil; experimental evidence suggests that cresylic acid emulsion or burning sulphur may be of use in cleaning glasshouses prior to planting.

3. Mosaic Disease Investigation.

By W. F. Bewley and W. Corbett.

The control of cucumber and tomato mosaics by the use of clean seed.

The importance of clean seed having been realised*, two glasshouses were erected at the Station for the purpose of cleaning existing stocks of cucumber and tomato seeds. For the purpose of the work, suspected stocks of Butcher's Disease Resisting cucumber and E.S. 1 tomato seeds were used.

Cucumber selection.

Seeds were sown on December 21st, 1927, in new boxes using a compost sterilised by heat. They were potted into size 32 pots a month later, and were planted in the special house on February 12th, 1928. Mosaic appeared on six plants early in March; these were immediately taken out and destroyed, as were any which appeared later. In all, 17 plants of the 100 planted developed the disease and were removed. From the beginning, two female flowers on each plant were pollinated; the seeds were extracted in April, keeping those from each plant separate. On pulling out the crop at the end of May there were eight consecutive healthy plants on each side of the north end of the house. Seeds were taken from two plants only in the middle of each batch. These seeds were used in the experimental houses during the 1929 season, and no sign of Mosaic disease appeared. Some of the seeds have also been tried on three commercial nurseries with similar results.

* Eleventh Annual Report, 1925. p. 36.

Tomato selection.

The E.S. 1 seeds were sown on December 21st, 1927; the seedlings were potted into size 60 pots on January 23rd, 1928, and planted into two separate houses on March 4th. Of 1,500 seedlings, 27 showed mosaic symptoms in the pot stage. Up to the third week in June, when seed was taken, 123 plants had been removed. The seeds from each plant were kept separate and those for future use were taken from twelve plants situated in the back rows and separated by at least three rows of healthy plants from spaces where infected plants had been removed. From these seeds 3,080 plants were grown during the season 1929 and showed no signs of Mosaic disease.

Definite evidence of seed transmission in the case of Mosaic disease of the tomato has long been sought. Preliminary experiments carried out during 1929 have been attended with some success.

Seeds saved from tomato plants severely infected with "Aucuba" mosaic were sown in July and out of the 496 plants raised 30 developed the disease, a percentage of 6·04. Every precaution was taken to prevent external infection through insects by constant fumigation and by keeping the plants in a separate chamber of the glasshouse.

Further experiments were conducted in which the embryos from seeds saved from a severely infected plant were inoculated into healthy tomato plants. The seeds were extracted from green fruits, were washed in 80% alcohol for 15 minutes and then in several changes of distilled water. The embryos were next taken out of the seeds, washed in running water for 24 hours and then crushed with a little distilled water and inoculated into healthy tomato plants. In the first experiment four out of six plants inoculated had developed the disease in 26 days; in a second experiment two out of sixteen plants inoculated developed the disease; and in a further experiment three out of eight plants inoculated developed the disease.

4. Soft Rot of the Arum.

By W. F. Bewley and W. Corbett.

Measures for controlling this disease by treating the dormant plants with formaldehyde and mercuric chloride solutions were given in the Seventh Annual Report, page 39, and in the Twelfth Annual Report, page 33.

Since that time they have been tested by commercial growers on a large scale.

The best results have been obtained with a 2% solution of formaldehyde (1 part 40% commercial formaldehyde in 49 parts water) as follows:—

(1) Shake the plant out of the dry soil and remove all roots from the corm.

(2) Wash in water, using a stiff scrubbing brush and a blunt piece of wood to scrape out the decayed portions of the corm.

(3) Steep the plants, leaves and corm in a 2% solution of commercial formaldehyde for two hours.

(4) Pot in sterilised soil, using pots sterilised in steam or by boiling in water.

(5) Sterilise the soil and superstructure of the houses with formaldehyde and stand the pots on tiles previously sterilised by heat or formaldehyde.

The last precaution is most important, and was determined as the result of experiments which Mr. F. W. Stiles very kindly conducted on his nursery at Goff's Oak. If the pots are not stood on tiles or similar material there is grave risk of re-infection.

3. Entomological Investigations.

1. Methods in practical use for the control of the more important Animal Pests of Glasshouse Plants.

By E. R. Speyer.

(a) Red Spider Mite.

(Tetranychus telarius L.*)*

Treatment for cucumber and tomato plants.

Spray with an emulsion of Petroleum (0·86 sp. gr., free from sulphur and products of oxidization) at a strength of 1 part emulsion to 80 parts water, within a period of 14 days after planting in the ground.

If necessary, repeat the spraying later at intervals of not less than three weeks.

It is essential to keep the plants well trimmed, otherwise injury may result from excess of oil upon cucumber foliage, and diseases such as dropsy and Botrytis-rot of tomato plants may be aggravated, especially if the water supply to the roots is not cut down, and as much ventilation as possible given.

At the end of the season, before the plants are removed, it is advisable to fumigate with crude Naphthalene, heated in special lamps, keeping the temperature of the glasshouses as high as economically possible, and using at least 10 ozs. crude Naphthalene for every 1,000 cubic feet space.

In cases of very severe infestation upon cucumbers during the growing season, fumigation with pure commercial white-flake Naphthalene (Grade 16) may be resorted to.

The Naphthalene is broad-cast upon the beds and paths at about 5 p.m. at the rate of at least 3 lbs. to 100 ft. run of border, after the plants have been thoroughly damped overhead, and watered at the root. Early next morning the ventilators are opened for a short period, to allow of thorough damping overhead, and closed again until the Naphthalene is volatilised; a second damping may be necessary in hot weather during the afternoon.

The success of fumigation depends largely upon a high moisture content in the atmosphere, and upon the temperature, which should not fall below 70°F. at any time during fumigation.

As cucumber fruits may taste of Naphthalene after fumigation, it is not advisable to cut fruit less than two clear days after the treatment is completed, but if it is necessary to do so, the fruit should be well aired for at least four hours before packing. Fumigation with Naphthalene is not suitable for tomato plants during the growing season.

Treatment for carnations and peach trees.

It is unsafe to use petroleum emulsions upon these plants. For small-scale spraying, allow 2 ozs. horticultural potash soft soap to dissolve in 2½ gallons of rain water (hard water must not be used) during the day; in the evening add 1 oz. liver-of-sulphur to the soap solution, stirring till all is dissolved. This spray must be used at once after the liver-of-sulphur is dissolved, as it deteriorates in a short space of time.

General cleanliness.

All staging, when not in use, should be kept in a dry shed; on no account should it be stacked amongst weeds or near hedges. The use of bamboo canes as plant supports is strongly deprecated; if it is essential to use them, they should be thoroughly sterilised by steam heat in a pressure boiler, or covered with a tarpaulin and a jet of steam introduced beneath it for a period of at least 20 minutes.

(b) White Fly (*Trialeurodes vaporariorum* Westw.).

The introduction of the Chalcid Parasite (*Encarsia formosa* Gahan) into glasshouses for the control of White Fly is rapidly becoming a popular method of keeping this pest in check.

Applicants for the parasite are asked to state the number of glasshouses for which it is required, and are especially reminded that the parasite will not become established unless White Fly is breeding in the houses at the time of introduction. The greatest advantage has been obtained from distribution of the parasite between the months of April and June inclusive, though it is possible to keep the parasite breeding during the winter if the temperature of the houses does not fall below 50°F.

The parasite is entirely harmless to plants and will not destroy pests other than the White Fly.

In cases of severe infestation by White Fly, when immediate control remedies are called for, fumigation with hydrocyanic acid gas or with tetrachlorethane may be carried

out without material harm to the parasite. The doses recommended for this purpose are:—

Cyanide Fumigation.

$\frac{1}{8}$ oz. to $\frac{1}{6}$ oz. Sodium cyanide is dropped into a jar containing $\frac{1}{2}$ fluid oz. 33% Sulphuric acid for every 1,000 cubic feet space.

Formula for measurement of cubic capacity of house:--

Capacity in cubic ft. = Length × Width × Average Height in ft.

$$\text{Average Height} = \frac{\text{Height to Gutter} + \text{Height to Ridge.}}{2}$$

Not more than $\frac{1}{2}$ oz. Sodium cyanide with the corresponding volume (2 fluid ozs.) of dilute acid should be used in a single jar. The hydrocyanic acid gas evolved is highly poisonous, and should on no account be inhaled.

Fumigation should be carried out at dusk and the ventilators opened at dawn next morning.

When fumigating numbers of houses in a block, one man is required to each house, to drop the weighed out Sodium cyanide into the jars which are placed at regular intervals upon the paths of the houses. Having closed the ventilators, the men employed should start at the same end of the block of houses at a given signal, and leave by the opposite door after dropping each charge of Sodium cyanide into its jar. The doors should be kept locked during the night, and the ventilators opened from outside at dawn, and kept open for at least half-an-hour.

Tetrachlorethane.

Five fluid ozs. to every 1,000 cubic feet space are poured upon the paths of the houses to be fumigated at dusk. This liquid must not be used when chrysanthemums, fuchsias, pelargoniums, azaleas, hydrangeas, and cinerarias are grown.

Status of the Parasite in 1929.

During the year, applicants in every county in England, and a number also in Wales, Scotland, Ireland and the Channel Islands were supplied with boxes of parasites. The total number of applicants supplied (exclusive of those supplied by local institutions to which large consignments were sent) was 578, as against 106 in 1928, and it is conservatively estimated that well over a million parasites were bred and distributed from the Experimental Station, as against some 400,000 in 1928.

Not more than one quarter of those who were supplied in 1928 required the parasite again in 1929.

The effect of the parasite upon White Fly in the Lea Valley has been most marked during the growing season of 1929; large nurseries which have been severely infested for years were supplied early in the season, as soon as the White Fly made its appearance, with the result that the glasshouses were practically cleared of the pest by the end of May, and remained entirely clean for the rest of the season. This was not due to seasonal conditions, as other nurseries which were not supplied, were severely infested by the month of August. Favourable reports have also been received from widely separated areas, including the Channel Islands.

During September, over 1,000 applications for the parasite were received; and the demand could not be met, as, under existing conditions, it is not possible to supply the parasite in sufficient numbers from that time until the end of March.

(c) Tomato Moth (*Polia oleraca* L.).

(1) Moth-trapping.

Two gallons of cheap light ale are mixed with 10 lbs. of thick dark treacle in a bucket. To this is added ½ lb. Sodium fluoride and the whole thoroughly stirred.

The mixture is poured into jars the mouths of which are at least 2 inches in diameter, at the rate of about 3 fluid ozs. per jar. The jars are hung from the bottom wires of tomato houses, and it is advisable to use at least eight jars to a house 150 feet in length The jars are placed in position as soon as the plants are placed in the ground, and dead moths and scum removed at frequent intervals. It is best to renew the bait entirely every month.

(2) Spraying.

Dissolve ¼ oz. Saponin in 1 pint of water and add this to 10 ozs. of lead arsenate paste, stirring vigorously so as to form a thin cream. The mixture is poured into 10 gallons of water in the spraying tank. The mixture must not be allowed to stand before spraying and is applied to the upper surface of the foliage. Two applications are recommended, the first three weeks after planting out, and the second not later than one month after the first. It is inadvisable to mix lead arsenate with petroleum oil emulsions, and on no account must it be used with sprays which contain any soap.

(3) General.

Market baskets should not be brought into the houses. In cases of severe infestation midway through the growing season, loosely folded sacks may be laid on the ground between the rows of plants and the caterpillars collected from them at frequent intervals. This is especially useful at the end of the season. The attempt at destruction of the chrysalids in the soil during the winter is not advocated, as large numbers of them are frequently parasitised by an ichneumon wasp. (*Pimpla instigator*).

(d) Vine Tortrix Moth (*Tortrix podana* Scop).

Light traps placed in vineries at night have been shown to attract such a small number of female moths, that no benefit is to be derived from their use.

The hanging up of moth-jars, as used for the Tomato Moth (see C (1) Moth trapping) is responsible for the destruction of numbers of female moths, and it has been proved that these are caught in the jars prior to laying their eggs.

The jars should be first hung up in the vineries not later than the end of April, and the bait renewed frequently until October. The most effective and certain control is obtained by repeated spraying with lead arsenate and Saponin as used for Tomato Moth caterpillar, for several weeks after the first foliage makes its appearance. This destroys the young caterpillars when they first come out to feed after lying hidden in crevices of the bark during winter.

Thorough application of the spray renders further control measures unnecessary.

(e) Woodlice (*Armadillidium speyeri* Jackson, *A. vulgari* Lat, *and Porcellio laevis* Lat.).

Since the use of a Paris-green bait came into practice for the destruction of Woodlice, severe infestations by these animals have been entirely eliminated.

To make the bait, 1 lb. commercial Paris-green powder is mixed thoroughly with 28 lbs. dry bran. As Paris-green is highly poisonous, it is best to get the bait mixed by a chemical manufacturer, and a glove should be worn when handling it.

The bait is broadcast evenly over the whole soil surface at the rate of about ½ oz. to the square yard; in cucumber houses the bait should be broadcast shortly after the plants have been watered, so that it remains dry as long as possible.

If the bait is placed in heaps, large or small, at intervals upon the ground or on staging, it is entirely useless.

Large quantities of the bait should not be thrown over the foliage of pot-plants, a little to each pot being sufficient, provided that it is also broadcast upon the ground beneath the staging.

Being poisonous to live-stock, this bait should not be used in gardens. For the control of Woodlice out-of-doors, a light dressing of pure commercial naphthalene in fine flakes is recommended. The Paris-green bait also kills Millipedes (*Orthomorpha gracilis* Koch) in cucumber beds, and is useful for Leather Jackets (*Tipula oleracea* L) which occasionally attack plants grown under glass. For the latter insect, enough water should be added to the bait to make a stiff mash before distribution.

(f) Wire-worms (*Agriotes obscurus* L., *A. lineatus* L., and *A. sputator* L.).

Trials carried out upon nurseries for the control of Wire-worm shortly before planting out tomato plants in the ground, showed that linseed cattle cake broken into pieces 4 ins. square and buried between the rows of plants to a depth of about 4 ins. at intervals of 2 ft. is superior to slices of carrot in attracting the Wire-worms, and is also very convenient to handle. It is not necessary to dig up the pieces of cake at intervals of less than one week, and, though liable to become mouldy, each piece will be serviceable for a period of at least three weeks.

The adult Click-beetles are readily attracted to mangolds cut in half and placed, cut face downwards, upon the soil surface; the beetles should be collected every morning during February and March.

(g) Cucumber Root-flies (*Pnyxia scabei* Hopk. and *Plastosciara perniciosa* Edwards).

The maggots of these flies are almost always present in potting soil, and in the soil of cucumber borders, but they only become injurious to the tap-root and lower portion of the stem if the soil is allowed to become too dry.

At the first sign of attack, shown by the wilting of the plants, the beds should be thoroughly flooded with water; the grubs die quickly in soil containing an excess of moisture. When pot-plants are attacked, all the pots in the propagating house should be allowed to stand in water for a period of 12 hours. The maggots of larger kinds of root-flies are more difficult to kill, but after immersion in water, they are not likely to attack the plant

(h) French-fly Mite (*Tyroglyphus longior* Box and Gerv.).

Temporary attacks of this Mite upon Cucumber plants in pots and shortly after planting out are easily controlled by sprinkling grade 16 naphthalene upon the path or borders at the rate of 3–4 ozs. per 1,000 cubic ft., and raising the temperature of the house for a period of two days. The pest is usually introduced into cucumber houses in the straw used for making up the borders. In sunlight and heat it ceases to breed.

(i) The Lucerne-Flea (*Smynthurus viridis* L.).

Occasionally introduced at the beginning of the growing season with the turf employed in making up cucumber borders, this small green hopping insect is best controlled by spraying the foliage with lead arsenate and Saponin, as for the Tomato Moth caterpillar, but using only 3 lbs. lead arsenate paste to 100 gallons of water. The insect neither breeds in cucumber houses, nor has it been recorded in them later in the year than March.

(j) Green Hedge-row Bug (*Calcoris norvegicus* Gmel.).

Introduced into propagating houses upon staging which has lain amongst weeds this bug sometimes causes serious damage to young cucumber plants. It has also been recorded as causing serious malformation of the upper growth of plants growing in borders made up with hedge-clippings. It is best controlled by spraying with Petroleum emulsion, as recommended for Red Spider Mite (1).

2. Red Spider Investigations on Commercial Nurseries.

By O. B. Orchard.

The migration and feeding habits of the Red Spider Mite having been investigated and discussed fully in the last two Annual Reports it is now possible, as the result of numerous experiments, to describe the most satisfactory means of controlling the mite under existing facilities. The measures described apply equally to cucumber or tomato crops.

When a nursery is known to have been infested with the mite the previous year, spraying with oil emulsions should be commenced at an early date. Success has attended the spraying of the ridges and upper portions of the roofs with the same spray several times, at intervals of three to four days, at about the time that the tomatoes are planted out from size 60 pots. The first application should be given to the plants when

they are about three months old, and subsequent sprayings conducted at monthly intervals. On nurseries where the mite has become firmly established, sprayings must be conducted at intervals of three weeks. Occasional sprayings applied indiscriminately have given very poor control. Successful control with oil emulsions depends on systematic spraying.

During April and May, as much ventilation as possible should be given when spraying, and the humidity of the house reduced for about three days as, owing to the luxuriant growth at that time of the year, oil emulsions tend to conserve the moisture in the foliage. At all times during the season it is advisable when possible to spray the plants after trimming rather than immediately before. There is a tendency to finish spraying operations for the season during August. This practice is strongly discouraged, and plants should be sprayed as long as they are green. At the time the last applications are given, it is advisable to spray the ridges and the roofs of the houses, as this prevents a great number of mites from reaching hibernation.

When it has not been found possible to carry out the above methods of control and, at the end of the growing season the spider mite has become severe, a mass attack should be made by fumigating with naphthalene. The most satisfactory method is by volatilisation from lamps, using 1 lb. crude naphthalene per 1,000 cubic ft. Fumigation should be conducted on bright and clear days, if necessary, using fire-heat to maintain a temperature of 70°F. for 24 hours. Slow volatilisation and low temperatures are to be avoided. Fumigation operations should be completed by the middle of October, or the mites will have reached their winter quarters, where naphthalene vapours will leave them untouched. The entire value of these Autumn fumigations lies in destroying the mites before they leave the plants. Once hibernation quarters have been reached the most thorough winter cleansing operations fail to dislodge all the mites.

By the courtesy of Mr. J. C. Cobley and with the assistance of Mr. W. H. Read of this Station, a series of naphthalene fumigation experiments were conducted during August on a crop of tomatoes infested with the spider mite, embracing varied conditions of temperature, light, humidity, duration of exposure, and rapidity of vaporisation. An effective control of the mite was obtained from a fumigation commencing at 3 p.m. on a very warm day early in August, using 12 ozs. of grade 16 naphthalene per 1,000 cubic feet. Under no conditions could the fruit be freed of the taste of naphthalene in less than five days.

Owing to this effect on the fruit, and the difficulty of obtaining suitable conditions for fumigation, the use of naphthalene as a fumigant for growing tomato crops cannot be regarded as an effective control measure under existing conditions.

Extensive investigations both in the laboratory and on commercial nurseries have, in all instances, failed to substantiate the theory that Red Spider Mite infestations result from the introduction of the mite in material such as straw, turf, and manure. In no instance has it been found that the mite can survive until the spring in the soil of glasshouses.

3. Fumigation Experiments with the Red Spider Mite.

By W. H. Read.

The examination of the action of the vapours of volatile substances on the Red Spider Mite has been continued. Although, as in previous years, a considerable number of substances have been found to kill the mite when used in small amounts (*i.e.*, up to 8 ozs. to 1,000 cubic ft.), their destructive action on the host plant renders them useless for practical purposes.

A systematic investigation of series of chemically related substances has been commenced and it is hoped that when completed an analysis of the results may elucidate some of the problems concerning the nature of the action of fumigants on this pest.

The results obtained by studying the aliphatic alcohols and their formic esters indicate that their activity increases with increasing molecular weight and that the killing power of the "normal" substance is greater than that of its isomers. In general it appears that the toxicity of members of a series of chemically related substances increases with increasing boiling point so far as the more volatile members are concerned. Methyl formate is an important exception, however, as it is the most active of the formates tested so far and also by far the most volatile.

Though the formates as a whole are poisonous to the mite, amounts varying from 3–10 ozs. per 1,000 cubic ft. yielding a complete control of all stages apart from eggs in laboratory tests, their destructive action on plants prevents their use as fumigants for growing crops.

Phenol-Soap Emulsions.

Samples of "low-temperature tar phenols" were kindly supplied by Professor C. T. Morgan, of the Department of Scientific and Industrial Research, and their effects upon the Red Spider Mite have been investigated.

Each sample was rendered emulsifiable by dissolving 40 parts of horticultural soft soap in 100 parts of phenol. Though emulsions of the members of lower boiling points yielded stable spray fluids on dilution with hard water the other members were unstable so that soft water was employed throughout.

The following results show the lowest strengths which will kill all the mites (apart from eggs) together with the limits beyond which stronger mixtures cause damage to tomato foliage. Series A. are the crude phenols and Series B. are corresponding samples from which resin-like substances have been removed. Results for emulsified cresylic acid are included for purposes of comparison:—

No. of Sample.	Boiling Point.	Lowest strength giving 100 % kill of mites.	Greatest strength at which no damage is caused to tomato foliage.
1A	200°–220° C	1 in 350	1 in 1200
2A	220°–240° C	1 in 250	1 in 750
3A	240°–260° C	1 in 250	1 in 1000
4A	260°–280° C	1 in 700	1 in 1200
5A	280°–300° C	1 in 900	1 in 1200
2B	220°–240° C	1 in 200	1 in 750
3B	240°–260° C	1 in 250	1 in 750
4B	260°–280° C	1 in 500	1 in 1000
5B	280°–300° C	1 in 600	1 in 1200
Cresylic acid	—	1 in 500	1 in 1100

Vegetable oil emulsions.

The use of vegetable oil emulsions for controlling the Red Spider Mite has been investigated during the past year. The relative efficiencies of the various oils, when emulsified with soap, were found by preparing emulsions by stirring 100 parts by volume of the oil with 20 parts of a standard 20% solution of potash soap. These emulsions were diluted with distilled water and the strength found at which a complete control of the mite (apart from eggs) could be obtained. The results were as follows:—Rapeseed or colza oil 1 in 120, "washed" cottonseed oil and refined cottonseed oils 1 in 105, linseed oil 1 in 120 and castor oil 1 in 80.

Whilst these figures show the relative efficiences of the oils when emulsified under standard conditions, they must not be regarded as indicative of their actual toxicities towards the mite.

Further work with rapeseed and cottonseed oils has shown that it is practically impossible to render soap emulsions of these oils stable in hard water by the addition of stabilising substances. Emulsions prepared with the emulsifying agents, such as sodium caseinate, gelatin glue, etc., are also unstable when diluted with hard water to spray strength unless the free acid is first removed from the oil.

A satisfactory emulsion for immediate use with soft water can be prepared by stirring 100 parts of washed cottonseed oil into 20 parts of a 20% solution of horticultural soft soap until no further thickening of the mixture can be felt. Control of the mite is obtained when this emulsion is used at a strength of 1 in 100.

More efficient emulsions have been prepared by the use of proprietary emulsifying agents of the sulphonated oil type. In this case the emulsifying agent is dissolved in the oil and the resulting mixture is added to the required amount of water in the spray tank to which has been added the alkali necessary to promote emulsification.

The amounts of emulsifying agent and alkali present depend on the hardness of the water, the extent of dilution, the nature of the oil and the amount of free acid present in it. Experiments have shown that pure rapeseed oil is more readily emulsified than is pure cottonseed oil, and these results are confirmed by studies of the interfacial surface tensions between the oils and neutral solutions of the ammonium salt of the sulphonated oil.

The presence of free acid in the oil increases the ease of emulsification but renders the resulting emulsion less stable with hard water. The presence in oil of free acid in amounts up to an equivalent of 15 mg. caustic potash per gram of oil was found to have no injurious action on plants.

The alkali salts of the sulphonated oil are insoluble in water and tend to form "water-in-oil" emulsions instead of the required "oil-in-water" emulsion so that effective emulsions in hard water can only be obtained by the use of large amounts of the emulsifying agent and alkali. Sodium carbonate may be used to promote emulsification but it was found that injury to tomatoes may result from the use of washing soda (sodium carbonate) in amounts exceeding 1 oz. in a gallon. When larger amounts of alkali were required on account of the hardness of the water it was found that ammonia yielded satisfactory results. When 10% by volume of sulphonated oil was added tor apeseed (colza oil) an effective

spray mixture was obtained by adding 8 fluid ozs. of the oil mixture to 10 gallons of *soft* water containing 8 fluid ozs. of 10% ammonia or $\frac{1}{4}$ lb. of washing soda. With hard water (20 degrees hardness) it was necessary to add 20% of sulphonated oil to the rapeseed oil and 30 fluid ozs. of 10% ammonia to each 10 gallons of the water.

In the case of cottonseed oil the above proportions are applicable for soft water, but with the hard water efficient emulsions were only attainable with 30% of sulphonated oil and 2 parts of 10% ammonia in each 10 gallons of water. This spray was found to cause injury to plants.

4. Chemical Investigations.

By O. Owen.

1. Soil Analysis, etc.

As in previous years a number of soils and water samples have been examined. It is interesting to note that there is a tendency amongst tomato growers to reduce the amount of lime applied each year. In some cases lime has been withheld from tomato soils for two years without affecting the crops. A new aspect of this problem has presented itself during the year under review. Three soils from different parts of the country were examined and in each case granules of calcium carbonate were present, but the main body of the soil was sour. This points to inefficient mixing and it suggests that all forms of lime should be applied in a fine state of division; the application being followed by the usual winter digging and flooding. It should be noted by growers that different soils require different forms of lime. Each soil must be judged on its own requirements, and where doubt exists samples should be submitted for examination.

Some samples from tomato houses have been found to contain undesirable amounts of chlorides. This can easily be avoided by analysis before the land is purchased. Samples of water examined have contained chlorides equivalent to between 8 and 11 gms. of sodium chloride per litre. The use of such supplies would ultimately lead to the accumulation of chlorides in the soil with eventual detriment to the plants and undesirable effects on the tilth. Nothing practical can be done to remove the chlorides from water and, where a nursery has been established, the only alternative is to seek a new supply of water of greater purity.

The following fertilisers, ordinarily in use at the Station, have been analysed:—Sulphate of potash, sulphate of ammonia, nitrate of potash, nitrate of soda, dried blood, bone meal, steamed bone flour, hoof and horn, basic slag, superphosphate and some "complete" fertilisers. In all cases the analytical figures were up to those required by the specifications.

2. The Analysis of Tomato Foliage.

At the end of the 1927 growing season the soil in House J at the Station was steamed and received no fertilisers for the 1928 crop. One effect of this, mentioned in the Director's Report last year, was to neutralise the differences ordinarily noticed in the A, B, C, D Plots following the different manurial mixtures applied. Samples of the foliage taken during 1928

were analysed and the results are of sufficient interest to warrant inclusion here. For the sake of comparison the figures for 1927 are given in Table 1. The results for 1928 constitute Table 2.

Table 1.

Plot.	Manurial Treatment.	Nitrogen.	Phosphoric Acid (P_2O_5)	Potash (K_2O)
J5A	Complete artificials	5·141	0·5577	7·273
J6A	Potash and nitrogen ; no phosphates	4·331	0·5358	5·592
J6B	Potash and nitrogen ; 8% phosphates	4·193	0·6604	6·351
J6C	Potash and nitrogen ; 16% phosphates	4·567	0·6443	6·520
J6D	Potash and nitrogen ; 24% phosphates	4·743	0·9399	6·040
J7A	Potash and phosphates ; no nitrogen	2·905	0·5538	3·580
J7B	Potash and phosphates ; 5% nitrogen	4·629	0·5697	5·416
J7C	Potash and phosphates; 7½% nitrogen	4·871	0·5291	5·751
J7D	Potash and phosphates; 10% nitrogen	5·660	0·6685	6·061
J8A	Phosphates and nitrogen ; no potash	2·905	0·9436	1·891
J8B	Phosphates and nitrogen ; 7½% potash	3·841	0·4414	4·163
J8C	Phosphates and nitrogen ; 10% potash	4·049	0·4254	4·658
J8D	Phosphates and nitrogen; 12½% potash	4·334	0·4648	5·669

The figures for 1927 indicate the anticipated effects of graduated additions of fertilisers. In addition they bring out two points which have already been mentioned in past reports, namely that the addition of phosphates increases the amount of potash in the foliage and the addition of potash reduces the amount of phosphoric acid in the foliage. In 1928, after steaming, these effects are not so evident. The foliage in the Plots J7 which for several years received varying amounts of nitrogen show very little difference in their nitrogen contents. Some variation is shown in the phosphoric acid values in Plots J6 which received varying amounts of phosphates and similarly there are some differences in the potash values where potash applications varied (J8). But in no case are these differences comparable with those observed in the foliage from the same plots during 1927, before steaming.

More decided are the differences in the mutual effects of potash and phosphoric acid under the two sets of conditions. In 1927, the omission of phosphates (J6A) is accompanied by a low potash content in the foliage. Addition of phosphates, while the potash applied remains constant, is accompanied by an increase in the potash content of the foliage (J6B, C and D).

In 1928, however, there appears to be no definite relation between the potash in the foliage and the previous manurial treatment. Again, in 1927, the omission of potash (J8A) is followed by a high phosphoric acid value in the foliage. In fact the figure is the highest in the whole series. Addition of

potash in the fertiliser is accompanied by a decided fall in the phosphoric acid figures (J8B, C, D) and a progressive increase in the potash values. In 1928 the same fall takes place in the phosphoric acid value but no definite increase occurs in the potash value.

Table 2.

Analyses of Dried Foliage of Plants in the different plots, 1928.

Plot.	Nitrogen.	Phosphoric Acid (P_2O_5).	Potash (K_2O).
J5	3·204	0·6287	5·546
J6A	2·543	0·6433	5·584
J6B	2·527	0·6557	4·697
J6C	2·499	0·5921	7·852
J6D	2·503	0·6895	4·772
J7A	2·313	0·7839	7·190
J7B	2·423	1·111	8·368
J7C	2·477	1·039	7·739
J7D	2·573	1·036	7·335
J8A	2·999	1·708	3·308
J8B	2·595	1·345	4·307
J8C	2·613	1·247	4·014
J8D	2·700	0·799	3·823

These facts suggest numerous possibilities and at the moment it is sufficient to explain them in the assumptions that steaming affects not only the availability of nitrogen but also of potash and phosphates, and secondly that conditions generally are so improved that the plant is able to make good use of the nutrients present.

5. Temperature Investigations.

1. General Observations.

By O. B. Orchard and W. F. Bewley.

An attempt has been made during the current year to determine the air and soil temperatures which exist in glasshouses of different types.

For this purpose, tomato House 1, of the ordinary vinery type, 100 ft. long, 26 ft. wide, with the gutters 5½ ft. and the ridge 13 ft. from the ground, and House 7 of the aeroplane type, 100 ft. long, 14 ft. wide, and 7½ ft. gutters were used.

Thermometers, previously standardised, were placed in the soil as shown in Figure 1. In all cases of soil records the readings have been taken at 6 ins. depth, except where otherwise stated.

Temperatures were recorded daily at 9.30 a.m., and the average weekly temperature calculated. Table 1 supplies the average daily soil temperature observed at the different situations in House 1, for 17 days. Table 2 provides the average weekly soil temperature for 40 weeks.

Table 1.

Date.	Position of Thermometers in House.					
	East Side.	Centre.	West Side.	North End.	Centre.	South End.
Mar. 19	49·8	52·5	50·5	50·3	51·5	51·5
,, 20	50·5	53·5	51·5	54·5	52·3	51·5
,, 21	53·0	56·0	53·5	54·5	55·3	55·3
,, 22	55·0	57·5	56·0	56·0	57·5	57·8
,, 23	56·0	57·0	57·5	57·0	56·8	56·8
,, 25	55·5	58·0	57·0	57·0	56·8	56·8
,, 26	56·2	59·0	57·5	58·0	59·0	59·0
,, 27	54·0	58·0	55·5	56·5	56·5	56·5
,, 28	55·0	59·6	56·0	59·0	56·7	56·3
April 2	57·0	59·5	57·5	58·3	58·3	58·2
,, 3	56·0	60·0	57·5	58·3	58·1	58·0
,, 4	55·0	58·5	56·5	57·5	56·8	56·5
,, 5	55·0	58·5	57·0	57·8	57·8	57·2
,, 6	53·5	57·0	55·5	56·5	56·5	57·0
,, 8	58·0	61·0	59·0	60·0	59·5	59·0
,, 9	57·0	60·0	58·5	59·0	58·8	59·0
,, 10	57·0	59·7	59·0	59·0	59·0	58·8

FIGURE 1.

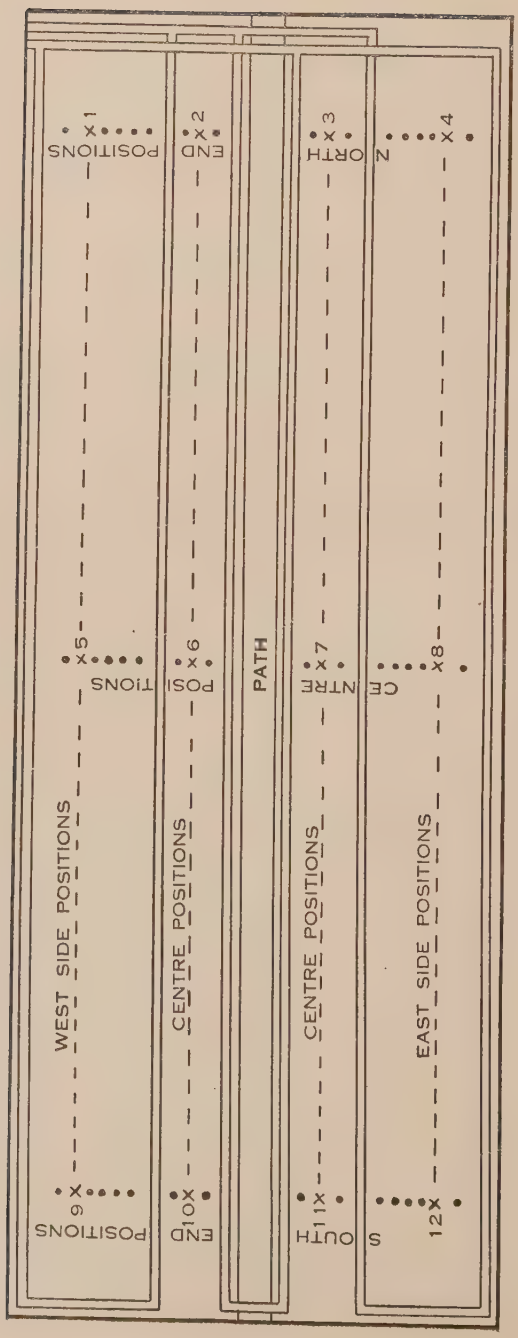

WEST SIDE POSITIONS
CENTRE POSITIONS
EAST SIDE POSITIONS
POSITIONS
END
PATH
SOUTH
NORTH
X 1
X 2
X 3
X 4
X 5
X 6
X 7
X 8
X 9
X 10
X 11
X 12
X DENOTES POSITION OF SOIL THERMOMETER

Table 2.

Week Ending.	°F	Week Ending.	°F	Week Ending.	°F	Week Ending.	°F
March 12	52·3	June 1	60·9	Aug. 10	60·8	Oct. 19	56·3
,, 23	53·7	,, 8	60·5	,, 17	61·7	,, 26	52·0
,, 28	57·1	,, 15	60·3	,, 24	61·8	Nov. 2	50·8
April 6	56·9	,, 22	61·7	,, 31	63·0	,, 9	50·6
,, 13	55·8	,, 29	59·5	Sept. 7	64·8	,, 16	46·1
,, 20	58·8	July 6	60·0	,, 14	63·5	,, 23	48·0
,, 27	58·2	,, 13	60·8	,, 21	62·7	,, 30	50·0
May 2	57·9	,, 20	65·3	,, 28	59·3	Dec. 7	48·8
,, 11	61·4	,, 27	65·2	Oct. 5	58·3	,, 14	48·3
,, 17	61·6	Aug. 2	62·0	,, 12	55·8	,, 21	43·3

It will be seen from Table 1, that the soil in the centre of the house was approximately 3°F.–4°F. warmer than that 3 ft. from the outside wall on the east side, and 2°F. warmer than that by the partition wall of glass on the west side. Also, the soil at the south end of the house was 1°F.-2°F. warmer than at the north end, the centre being almost always the same as the south end. This house was not artificially heated until March 5th, and it was found that the difference in temperature between the north and south end was fairly constant until, but not after March 12th. This fact was probably due to more uniform heating of the atmosphere of the house owing to the higher position of the sun. Further experiments may show that as the house becomes warmed by artificial heat, the temperature of the soil becomes more uniform throughout the house. A striking feature of the temperature records is the degree of fluctuation in various parts of the house, which were traced to various external influences such as direct sunlight, wind, rain, etc.

Tables 3 and 4 give the average daily soil temperature and the average weekly soil temperature respectively in House 7. Comparing these with the observations in House 1, it is seen that

(1) The difference in temperature of the soil at the north and south ends of the house is not so pronounced in No. 7 as in No. 1.

(2) The east side of both houses is an outside wall, and the soil three feet from it is warmer than on the east side by approximately 2°F.–3°F.

(3) The soil temperature of No. 7 was 2°F.–3°F. warmer than No. 1 until the end of April. After July 1st the soil temperature of both houses became alike.

Table 3.

Date.	Position of Thermometers in House.				
	North End.	Centre.	South End.	West Side.	East Side.
Mar. 19 ...	53·7	54·0	56·5	55·0	54·5
,, 20 ...	55·0	56·5	57·0	56·0	55·6
,, 21 ...	57·0	57·0	59·0	57·6	57·6
,, 22 ...	60·0	59·0	60·0	59·3	60·0
,, 23 ...	58·0	58·5	59·5	58·6	59·0
,, 25 ...	59·5	58·5	60·5	59·6	59·3
,, 26 ...	60·0	59·0	60·0	59·3	59·3
,, 27 ...	60·0	65·5	60·5	59·6	61·6
,, 28 ...	59·5	59·0	61·0	60·3	59·3
April 2 ...	59·5	58·5	60·5	60·0	59·0
,, 3 ...	59·0	56·5	58·0	57·3	57·0
,, 4 ...	57·5	55·5	57·5	57·3	56·3
,, 5 ...	57·0	55·5	56·5	57·3	56·3
,, 6 ...	66·0	65·0	66·0	65·7	65·7
,, 8 ...	60·5	60·5	63·0	59·0	59·0
,, 9 ...	59·5	58·0	59·5	59·0	59·0
,, 10 ...	60·0	59·5	59·5	59·6	59·6

Table 4,

Week Ending.	° F	Week Ending.	° F	Week Ending.	° F	Week Ending.	° F
March 12	57·1	April 20	60·0	June 1	61·4	July 6	60·5
,, 23	57·8	,, 27	59·4	,, 8	61·2	,, 13	60·6
,, 28	60·2	May 4	59·4	,, 15	61·3	,, 20	64·8
April 6	57·6	,, 11	62·5	,, 22	62·4	,, 27	65·4
,, 13	58·4	,, 17	62·3	,, 29	65·4	Aug. 2	63·3

Table 5.

Date.	Temp. of Soil ° F	Date.	Temp. of Soil ° F	Date.	Temp. of Soil ° F	Date.	Temp. of Soil ° F
March 4	42·8	March 7	49·5	March 11	52·8	March 21	55·0
,, 5	40·0	,, 8	49·0	,, 19	51·0	,, 22	57·0
,, 6	46·5	,, 9	50·8	,, 20	53·0	,, 23	56·8

Table 5 shows the rate of heating the soil in House 1, fire heat being applied on March 5th. The temperatures shown are the mean readings from twelve thermometers, and are given until March 23rd when it was found that the soil temperature remained constant.

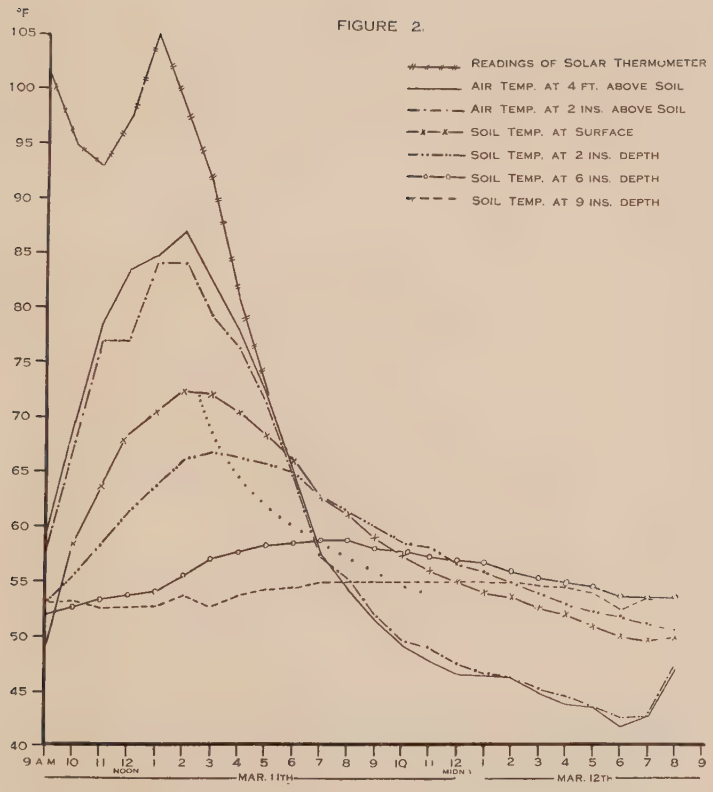

°F
105
100
95
90
85
80
75
70
65
60
55
50
45
40
9 AM 10 11 12 NOON 1 2 3 4 5 6 7 8 9 10 11 12 MIDN 1 2 3 4 5 6 7 8 9
MAR. 11TH
MAR. 12TH
READINGS OF SOLAR THERMOMETER
AIR TEMP. AT 4 FT. ABOVE SOIL
AIR TEMP. AT 2 INS. ABOVE SOIL
SOIL TEMP. AT SURFACE
SOIL TEMP. AT 2 INS. DEPTH
SOIL TEMP. AT 6 INS. DEPTH
SOIL TEMP. AT 9 INS. DEPTH

FIGURE 2.

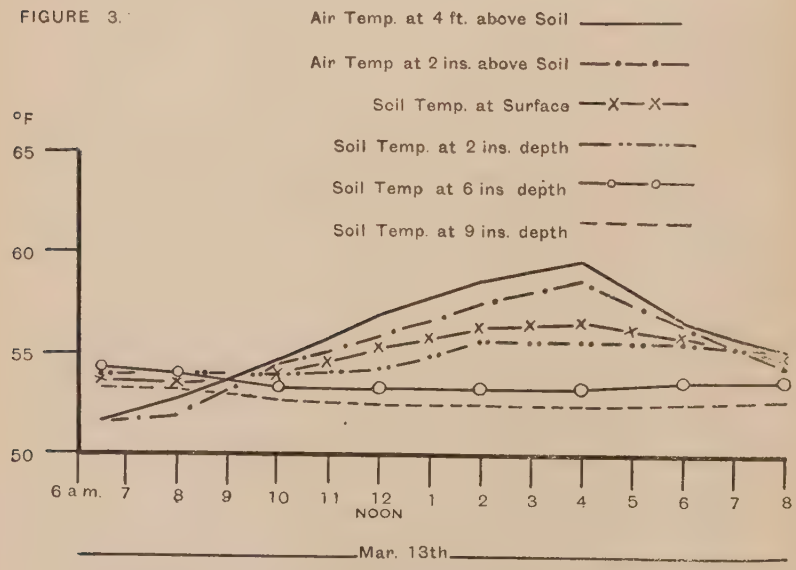
Variation in air and soil temperature.

Figure 2 shows the variation which occurred in House 1 over a period of 24 hours, beginning at 9 a.m. on March 11th, a day of continuous sun. The house was planted on March 12th.

Observations were recorded hourly, and show a surprising rise and fall of air temperature, a difference of 45°F. occurring between 2 p.m. and 6 a.m. the following morning. Under the conditions prevailing in this instance, it is seen that on a cloudless day the surface soil which is warmed by radiation reaches a maximum temperature shortly after solar heat has reached a maximum. The lower layers, heated by conduction from the surface attain their maximum temperatures after intervals which vary with their depth, as shown by the dotted line on the graph. By interpolation it may be shown that there was no warming of the soil on this occasion, at a depth of slightly over thirteen inches.

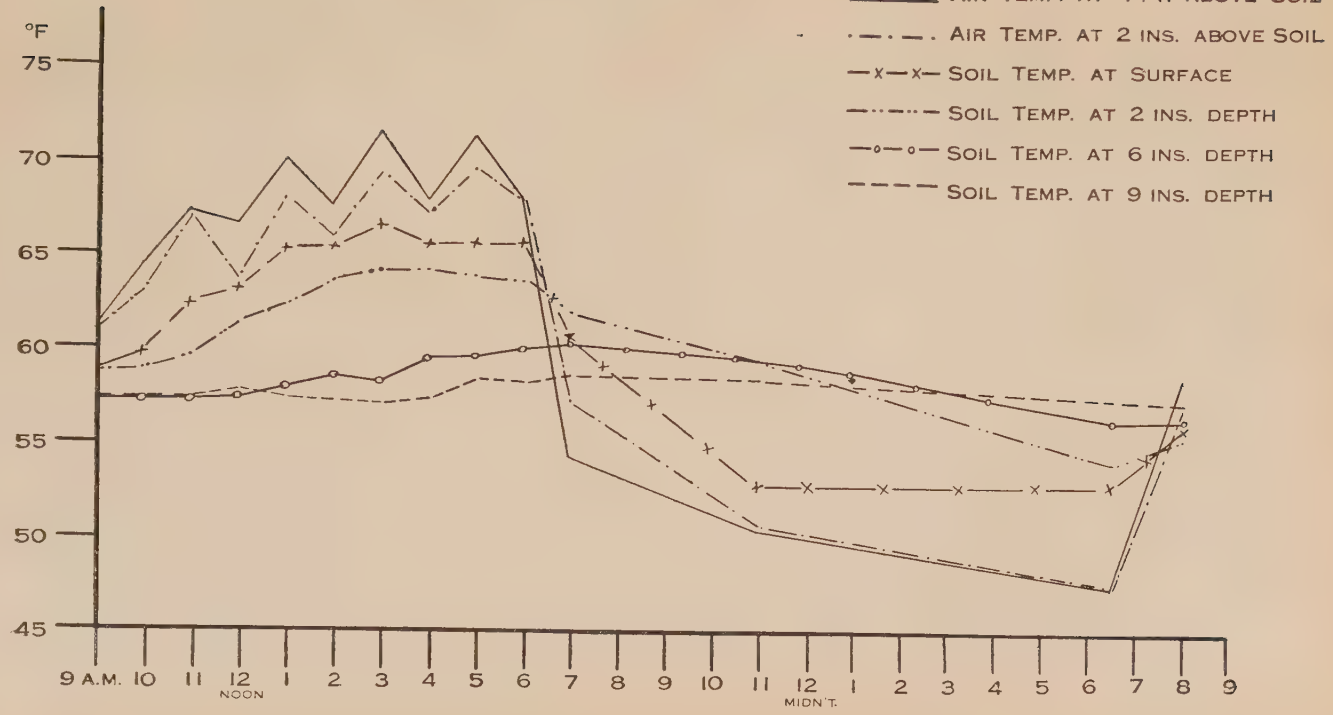
Figure 3 was made from observations recorded on March 13th, a sunless day. It is noticeable that although the temperature of the surface layers of the soil and the air temperature approximate very closely, there is actually a slight loss of heat from the soil at a depth of 6 in. and 9 in. during the day.

FIGURE 3.



Records taken on April 16th, although a month later, show very similar changes in soil temperature at various depths throughout the day, as occurred on March 13th. Figure 4.

FIGURE 4.


AIR TEMP. AT 4 FT. ABOVE SOIL
AIR TEMP. AT 2 INS. ABOVE SOIL
SOIL TEMP. AT SURFACE
SOIL TEMP. AT 2 INS. DEPTH
SOIL TEMP. AT 6 INS. DEPTH
SOIL TEMP. AT 9 INS. DEPTH
°F
75
70
65
60
55
50
45
9 A.M. 10 11 12 NOON 1 2 3 4 5 6 7 8 9 10 11 12 MIDN'T. 1 2 3 4 5 6 7 8 9

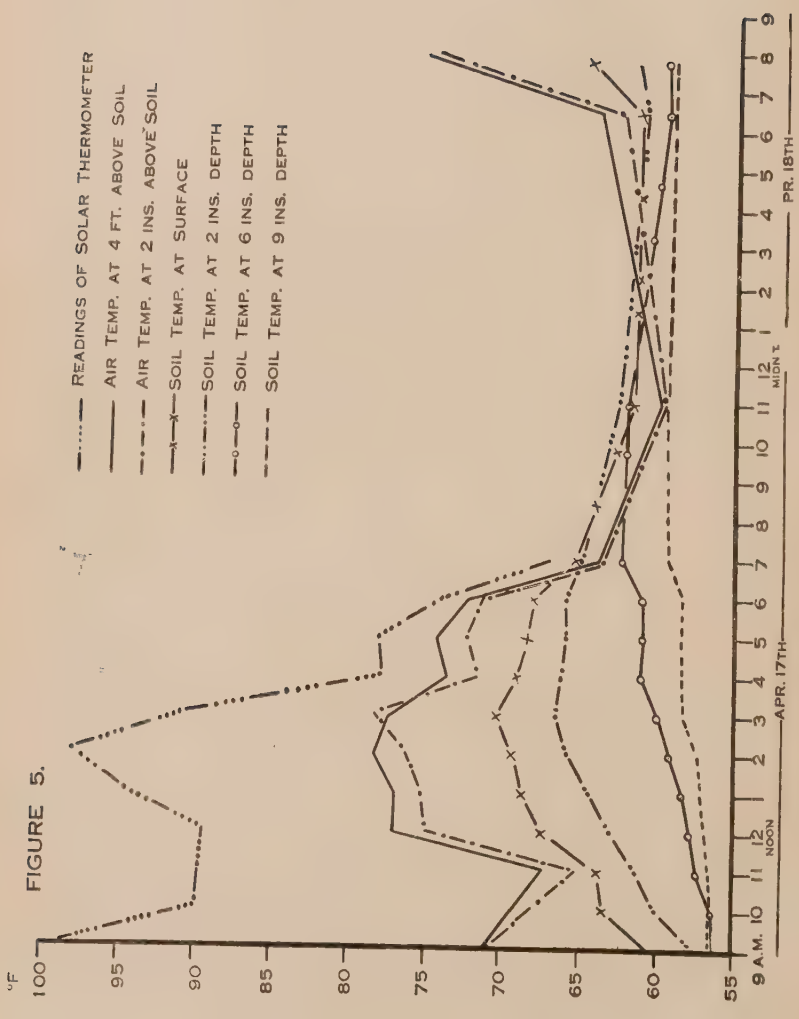

°F
100
95
90
85
80
75
70
65
60
55
9 A.M. 10 11 12 NOON 2 3 4 5 6 7 8 9 10 11 12 MIDN'T 1 2 3 4 5 6 7 8 9
APR. 17TH
PR. 18TH
READINGS OF SOLAR THERMOMETER
AIR TEMP. AT 4 FT. ABOVE SOIL
AIR TEMP. AT 2 INS. ABOVE SOIL
SOIL TEMP. AT SURFACE
SOIL TEMP. AT 2 INS. DEPTH
SOIL TEMP. AT 6 INS. DEPTH
SOIL TEMP. AT 9 INS. DEPTH

FIGURE 5.

Similar observations were made in the same house on April 17th, a day of continuous sunshine, when factors such as ventilation of the house and shading of the soil by plant growth were involved. Figure 5. Maximum air temperatures did not rise so high as on March 11th, but this may be attributed to ventilation. Although the maximum temperature of the surface soil layers was the same as on March 11th, the temperature of the soil at 6 and 9 inches had risen 3·7°F. and 4·2°F. respectively.

It is noticeable that each day these observations were recorded a rise in soil temperature persisted at a depth of 6 to 9 inches after the temperature of the surface layers was falling, due to conduction from the upper layers, which, though falling, remain warmer for a period of roughly six hours. Though factors such as radiation from the soil to the cold roof; loss of water due to the transference by evaporation from the soil, and condensation on the glass undoubtedly influence the soil temperatures, their extent has not been ascertained in detail.

Difference in temperature between fallow and cultivated plots.

Daily readings throughout the period May to October from a fallow plot in House 8, receiving the same cultural treatment as a cultivated plot in the same house, show that the former maintained an average temperature of 4°F. above the latter. The tomato plants were 3 feet high when the observations commenced, but the difference in temperature persisted throughout the season irrespective of the height of the plants. The temperature of the plots became alike about the middle of October, coinciding with the collapse of the plants.

Variation of air temperatures.

Observations recorded in House 1 at intervals throughout the season show that, at the same height, air temperatures vary very little in various parts of the house. The effect of direct sunlight appears to be the chief factor governing variation. A morning sun with a sunless afternoon brings the maximum temperature of the west side of the house above that of the east, a sunless morning with sunshine during the afternoon having the reverse effect.

Although the maximum temperature at a height of 5 feet, or any place close to the glass, often rises from 2°F. to 10°F. above that at the soil surface the minimum at the latter position does not fall so low by several degrees, varying with the amount of sunshine during the day, humidity and consequent radiation from the soil surface.

Comparisons between House 1 (a self-contained house) and House 4 (an open house in a block of five), show the mean temperatures at a height of 5 feet to approximate very closely. The only noticeable difference was that the minimum air temperature at the surface of the soil was consistently 2°F. higher in House 4 than in House 1.

The maximum soil temperature of 68°F. occurred on July 22nd, on which day the soil temperature in both types of houses under observation was the same. Outside soil temperatures are recorded daily at this Station, and at a depth of 1 foot the maximum temperature of 67·4°F. also occurred on July 22nd.

2. Air Temperature.

By O. B. Orchard and W. F. Bewley.

The experiments commenced during 1928 in House 6 to ascertain the best air temperature for the tomato crop, were continued during the current year. Chamber No. 1 was used for carbon dioxide experiments, and at the beginning of the season, chambers Nos. 2, 3, 4, 5 and 6 were arranged to work at a minimum night temperature of 63°F., 63°F., 63°F., 60°F., and 55°F., respectively. After the second truss had set, chambers Nos. 2 and 3 were regulated to maintain a minimum night temperature of 70°F. and 65°F. respectively, the other chambers remaining as previously.

Sixty plants of the variety Craigwood were planted in each chamber on March 20th.

The following table shows the weights of crops obtained from the different chambers.

Table 1.

Chamber No.	Minimum Night Temp. °F	Pounds per Plant.							Tons per Acre.
		May.	June.	July.	Aug.	Sept.	Oct.	Total.	
2	70	0·14	1·34	1·20	0·84	1·00	0·24	4·76	36·17
3	65	0·09	1·72	1·53	0·78	0·88	0·13	5·13	38·97
4	63	0·08	1·30	1·47	0·94	0·51	0·29	4·59	34·88
5	60	—	0·94	2·28	0·80	0·57	0·28	4·87	37·01
6	55	—	0·62	1·96	0·79	1·57	0·40	4·34	32·98

No marked difference could be seen in the growth or appearance of the plants in any chamber. This was probably due to the fact that for the first six weeks the mean night temperature approximated very closely.

In the following Table (Table 2) the weekly mean day and night temperatures are given for the period during which the chambers were heated artificially.

Table 2.

Weekly Mean Day and Night Temperatures °F.

Week Ending.	Chamber No. 2.		Chamber No. 3.		Chamber No. 4.		Chamber No. 5.		Chamber No. 6.	
	Day.	Night.	Day.	Night.	Day.	Night.	Day.	Night.	Day.	Night.
Mar. 10	56·0	45·4	58·6	42·7	58·2	43·2	60·7	43·2	58·8	41·1
,, 17	59·7	56·8	58·6	55·0	57·0	53·4	57·2	53·0	56·8	49·0
,, 24	66·0	64·8	70·4	73·0	72·1	63·7	67·8	60·2	68·8	60·5
,, 31	77·9	66·6	75·8	61·4	80·0	63·0	71·0	60·2	71·0	58·4
April 8	70·0	60·8	70·6	59·2	71·8	59·0	66·7	56·1	67·0	54·6
,, 14	70·5	66·2	72·2	61·9	72·0	65·5	65·0	59·2	66·1	60·8
,, 22	78·0	61·5	74·5	66·0	78·0	71·0	74·2	62·5	74·6	60·8
,, 29	73·8	66·0	70·5	63·0	71·1	60·8	71·6	60·8	71·0	61·0
May 6*... ...	77·8	66·0	69·4	63·0	69·9	60·2	66·8	61·5	72·4	58·0
,, 13	82·5	70·5	77·5	64·8	78·0	66·5	76·8	64·1	73·4	64·8
,, 20	83·4	64·6	71·2	64·3	85·0	63·6	73·8	61·3	81·8	64·3
June 10	78·8	63·0	71·0	64·0	74·2	64·6	72·5	57·5	75·0	59·8
,, 17	76·0	67·0	68·2	64·5	76·4	64·2	75·2	53·9	68·8	61·7
,, 24	78·6	65·8	73·8	63·2	74·5	65·5	76·9	63·5	76·9	62·7
July 1	76·8	65·0	66·0	64·2	75·5	64·2	75·8	65·5	75·7	61·0

* First week of running No. 2 and 3 at higher temperatures.

3. Effect of Increasing Soil Temperature.

By O. B. Orchard and W. F. Bewley.

This experiment, begun in 1927, was continued during the past year in Houses 8 and 9. As described in the Annual Report, 1928, electric resistance cables were buried in four plots at a depth of 16 inches which enabled the temperature of the soil to be kept at 65°F., 70°F., 75°F. and 80°F. respectively. Fire heat was applied to this block of houses on February 14th, the tomatoes being planted on March 7th. To warm the soil to the required temperature the electric cables were heated on March 9th for 50 hours, after which period the time switch was put into operation, automatically applying the current from 10 p.m. to 6 a.m. Plots A, B and C failed to respond to heating, the cables having deteriorated during the winter. Plot D (Plot 1, House 8) was heated until May 7th and readings from three thermometers recorded daily, show a mean weekly temperature closely approximating to 80°F. Plot 8, House 7, was used as the control plot for estimating the weight of crop obtained, the results being shown in the following Table:—

Plot.	Temp. °F	Pounds per Plant.						Total lbs. per Plant.	Total Tons per Acre.
		May.	June.	July.	Aug.	Sept.	Oct.		
D	80	0·05	1·72	3·67	0·70	0·99	0·70	7·83	59·50
Control	58	0·03	1·31	2·83	0·53	0·90	0·89	6·49	49·33

The plants in the heated plot (60 in number) quickly showed the effect of increased soil temperature. Eighteen days after the first heating they were 4 to 6 inches taller than those of the control plot, the growth being very soft and of a light green colour. The flowers of the first truss opened about a week earlier than those of the control plot. Thirty days after planting, the fruits of the first truss on the plants in Plot D were about the size of hazel nuts, while those of the control plot had hardly commenced to swell, but the first ripe fruit was gathered from both plots on the same day.

An examination of the above Table, however, shows that the fruit of Plot D matured much faster than that of the control plot, and that the total crop was 20·7% higher.

6. Miscellaneous Investigations.

1. The Blooming and Fruiting Period of the Tomato Plant.

By M. Jozefowicz and W. Corbett.

Work begun on this subject in 1925 and continued in 1926 and 1927 has been further continued during the season 1929.

Records were made as in previous years; these included:

(1) The date of opening of each flower, and

(2) The date of picking of each fruit.

The work of past years has been repeated in part, and this year plants stopped at the fifth truss, as is the general practice, were compared with plants allowed to grow unstopped. All plants were of Variety E.S. 1 and were situated in the Variety Trial House, two rows at the north end, one on each side of the house and two rows at the south end, also one on each side of the house. The plants received normal treatment so far as manuring, etc., were concerned. Records of the opening of flowers were made until 31st July, and records of the picking of fruit until the plants were removed at the end of the season.

In 1925 it was found that the "maturation period" (*i.e.*, the time taken between the opening of the flowers and the picking of the fruit) was not constant for every fruit on the plant; instead, all the fruits of the first truss and the first six or seven fruits of the following trusses (up to the fifth truss) ripened in approximately the same length of time, whereas in the case of the later fruits of the second, third and fourth trusses there was a prominent increase in the length of the "maturation period." These results were confirmed in 1926 and 1927 and it was also found that in the case of an abnormally robust and healthy plant, the "maturation period" of all the fruits on the plant approached a constant. These results have again been confirmed.

The effect of stopping on the maturation period.

From the results of 1927 it was concluded that stopping after the first or second truss was advantageous, while plants stopped after either the third or fourth trusses showed the usual "maturation period" variations.

Records were again taken of plants which were stopped at varying times, from the first truss up to the fifth truss, and also of plants stopped after the third truss, and of plants where each truss was stopped after the eighth fruit.

The results do not confirm those of 1927 but indicate that stopping at the third truss may be advantageous. Stopping each truss after the eighth fruit gave good results and the usual variations did not occur. This might be expected since the more fruits occurring on the truss the greater variation in the "maturation period" of the fruits.

Stopping or non-stopping.

With two rows of plants, one at each end of the house, every other plant was allowed to grow on without being stopped. The results do not show any benefit accruing from allowing plants to grow straight on, the usual "maturation period" variations occurring in all the plants, stopped or not stopped.

North end v. south end of house.

A striking result has been obtained this year in comparing the "maturation period" of the fruits of plants grown at different ends of the house, otherwise receiving the same treatment. The "maturation period" of the fruits of the plants at the south end shortens with successive trusses (this is most marked) while with the plants at the north end there is little or no difference.

2. The History of the Tomato.

By W. Corbett.

Until the middle of the sixteenth century no mention of the tomato occurs in any literature, so it may be assumed that its introduction to Europe was not until the end of the fifteenth or beginning of the sixteenth century. It is probable that it was brought back from America by Columbus on his return after his second voyage of discovery (1498) for there is little doubt that it is a native of South America.

The first reference to the tomato is made by Matthioli ("Medici Senensis Commentarii," 1554) who says that it had but recently appeared in Italy. He calls it *Mala aurea* and Pomi d'oro, the apple of gold.

Some three years later (1557) Dodoens published his "Histoire des Plantes" and gives the first full description of the tomato, calling it "Pomme d'amour" or "love apple." He also says that it is a foreign plant and only to be found in the gardens of certain herbalists.

The date of introduction of the tomato into England is generally given as 1596, but it was probably earlier. The first record of its being grown in this country is in Gerarde's

"Catalogue" (1576). Gerarde had then actually grown tomatoes in his garden, and as he was Superintendent of the gardens of Sir Robert Cecil, afterwards Lord Burleigh, at Theobald's Palace, Waltham Cross, it is highly probable that this was one of the first places where the tomato was grown in this country, and now it stands in the centre of the largest tomato growing area in the world.

In Gerarde's "Herbal" (1597) can be found the first description of the tomato in the English language. He calls them "Apples of Love," *Poma amoris*. The description given here closely resembles that of Dodoens.

The next English author to make mention of the tomato is John Parkinson, who in his "Paradisus" (1629) says, "We only have them for curiosity in our gardens, and for the amorous aspect or beauty of the fruit."

After Parkinson no English author mentions the tomato until Miller's "Gardener's Dictionary" was published in 1735. Five varieties are described and, in a later edition (1768) two more varieties are mentioned, *Lycopersicon pimpinellifolium* and *L. Peruvianum*.

All the authors from Matthioli to Miller say that the fruit of the tomato was eaten but they are almost all of the opinion that they "give little and bad nourishment." Gerarde in his "Herbal" says that, "In Spain and those hot regions they use to eat the apples . . . . but they yield very little nourishment to the bodie, and the same naught and corrupt." Miller also says, "the nourishment they afford must be bad."

It is mentioned by some authors (Matthioli 1586 and Cameraris 1588) that the fruit cooked in oil and dried in the sun was used as a cure for scabies. Parkinson mentions this fact, and in Miller's time the tomato was apparently grown in this country for medicinal purposes, for he says, "The first of these plants (*Lycopersicon Galeni*, yellow love apple) is the sort directed for medicinal use by the College in their dispensatory."

After Miller the next author to write about the tomato was Sabine (1822), who gives cultural directions and says that the fruit were then being grown for market. He says that Willmott, of Isleworth, a well-known gardener, was growing them for market, and that from 600 plants were picked more than seven tons of fruit; individual fruits were of extraordinary size, some being 12 in. in circumference and weighing 12 ozs.

From this time onwards the popularity of the tomato increased rapidly, from being considered dangerous to eat, to its widespread popularity.

3. The Preparation of Tomato Seed.

By W. H. Read.

The extraction of tomato seeds from ripe fruits is usually performed by placing the seeds and surrounding "pulp" in a convenient receptacle and leaving it to ferment for a few days, to break down the mulicaginous material so that the seeds may be cleaned by washing in water. The rate at which the mucilage is destroyed varies considerably with different batches, being governed mainly by the temperature of the fermenting mass. Prolonged fermentation adversely affects the germination power of the resulting seed, and it seemed necessary to devise some simple means for removing the mucilaginous coating in a short time.

It has been found that by soaking the seeds for a short time in solutions of various substances the mucilage is readily removed by washing with water. Of these substances, sodium carbonate (washing soda) is of most importance in view of its non-injurious action on the seed, and the following process is suggested as an alternative to the older method:—

The mass of seed extracted from ripe fruits is well mixed with an equal volume of a 10% solution of washing soda (sodium carbonate). After standing for a period which varies very considerably with the temperature at which the mixture is kept and to a lesser extent with other factors, the mucilage or fleshy covering surrounding each seed is completely removed by washing with water. The seeds are then dried on sheets of glass in the ordinary way.

The following figures resulting from numerous tests at the various temperatures, show the time the mixture must be left to enable the seed to be thoroughly cleaned on washing with water:

TEMPERATURE.		TIME.
140°F.	...	5—10 mins.
120°F.	...	10—35 mins.
105°F.	...	25—70 mins.
85°F.	...	30 mins.—3 hrs.
68°F.	...	2 hrs.—8 hrs.
59°F.	...	4 hrs.—18 hrs.

Methods whereby temperatures of 100°F.—140°F. can be simply and safely obtained are being investigated.

Though no results are at present available as to the effect of prolonged storage on seeds treated with sodium carbonate it has been found that soaking in 20% sodium carbonate for 3 hours at 140°F., 12 hours at 120°F., 24 hours at 105°F., or 4 days at 68°F., had no effect on the germination or subsequent growth of seedlings from seeds sown a few weeks after treatment. It should be noted, however, that the seed is usually darkened in colour by this treatment.

APPENDIX A.

Manurial Treatment in the Tomato Experiments.

(1) Lime.

All Houses except No. 11 received ground caustic lime at the rate of 2 tons per acre.

(2) Stable Manure.

Houses No. 2, 5, and 6 received stable manure at the rate of 30 tons per acre.

(3) Base-dressing.

Houses Nos. 2 and 5 received ¾-lb. per sq. yd. of the following mixture :—

1 part bone meal.
1 part bone flour.
1 part ground hoof and horn.
1 part sulphate of potash.

Houses Nos. 6, 7, 8, 9, 11, and 12 received the following per sq. yd. :—

¼-lb. bone meal.
¼-lb. bone flour.
¼-lb. sulphate of potash.

(4) Top-dressing.

Houses Nos. 2, 5, 6, 7, 8, 9, 11, and 12 received 2 ozs. per sq. yd. of the following mixture every 14 days at discretion :—

3 parts sulphate of ammonia.
2 parts dried blood.
7 parts 30 % superphosphate.
5 parts pure dissolved bones.
½ part bone flour.
2½ parts sulphate of potash.

This gave 5 % ammonia, 24 % total phosphates, 12 % soluble phosphates, and 7 % potash on examination.

Manures applied in Series J. and K.

Plot.	TITLE.	Base Manure in Lbs. per sq. yd.							† Top-dressing in Lbs. per sq. yd.			
		Lime.	Stable Manure.	Basic Slag.	Bone Meal.	Bone Flour.	Ground Hoofs.	Sulphate of Potash.	Super-phosphate.	Sulph. of Ammonia.	Nitrate of Soda.	Sulph. of Potash.
§J2a	Unmanured	1.0	—	—	—	—	—	—	—	—	—	—
J2b	Unmanured	1.0	—	—	—	—	—	—	—	—	—	—
J2c	Stable Manure	1.0	28	—	—	—	—	—	—	—	—	—
J3a	Sulphate of Potash only	1.0	—	—	—	—	—	—	—	—	—	0.4
J3b	2½% Nitrogen and 10% Potash	1.0	—	—	—	—	—	—	—	0.2	—	0.4
J3c	5% Nitrogen and 10% Potash	1.0	—	—	—	—	—	—	—	0.4	—	0.4
J3d	7½% Nitrogen and 10% Potash	1.0	—	—	—	—	—	—	—	0.6	—	0.4
J4a	Sulphate of Potash and Superphosphate	1.0	—	—	—	—	—	—	0.3	—	—	0.4
J4b	2½% Nitrogen, 5% Superphosphate, 10% Potash	1.0	—	—	—	—	—	—	0.3	0.2	—	0.4
J4c	5% Nitrogen, 5% Superphosphate, 10% Potash	1.0	—	—	—	—	—	—	0.3	0.4	—	0.4
J4d	7½% Nitrogen, 5% Superphosphate, 10% Potash	1.0	—	—	—	—	—	—	0.3	0.6	—	0.4
J5a	Complete Artificials (Formula II.)	1.0	—	0.4	—	—	—	0.1	1.3	0.4	—	0.3
J5b	Complete Artificials and Grass	1.0	—	0.4	—	—	—	0.1	1.3	0.4	—	0.3
J6a	Complete Artificials (II.) without Phosphates	1.0	—	—	—	—	—	0.1	—	0.4	—	0.3
J6b	Complete Artificials (II.) with 8% Phosphates	1.0	—	—	—	—	—	0.1	0.8	0.4	—	0.3
J6c	Complete Artificials (II.) with 16% Phosphates	1.0	—	—	—	—	—	0.1	1.3	0.4	—	0.3
J6d	Complete Artificials (II.) with 24% Phosphates	1.0	—	—	—	—	—	0.1	1.7	0.4	—	0.3
J7a	Complete Artificials (II.) without Nitrogen	1.0	—	0.4	—	—	—	0.1	1.3	—	—	0.3
J7b	Complete Artificials (II.) with 5% Nitrogen	1.0	—	0.4	—	—	—	0.1	1.3	0.4	—	0.3
J7c	Complete Artificials (II.) with 7½% Nitrogen	1.0	—	0.4	—	—	—	0.1	1.3	0.6	—	0.3
J7d	Complete Artificials (II.) with 10% Nitrogen	1.0	—	0.4	—	—	—	0.1	1.3	0.8	—	0.3
J8a	Complete Artificials (II.) without Potash	1.0	—	0.4	—	—	—	—	1.3	0.4	—	—
J8b	Complete Artificials (II.) with 7½% Potash	1.0	—	0.4	—	—	—	—	1.3	0.4	—	0.3
J8c	Complete Artificials (II.) with 10% Potash	1.0	—	0.4	—	—	—	—	1.3	0.4	—	0.4
J8d	Complete Artificials (II.) with 12½% Potash	1.0	—	0.4	—	—	—	—	1.3	0.4	—	0.6
K1	Double Complete Artificials (Formula I.)	1.0	—	0.8	—	—	—	0.2	1.0	0.4	0.4	0.4
K2	Unmanured	1.0	—	—	—	—	—	—	—	—	—	—
K3	Complete Artificials (I.) with Standard	1.0	14	0.4	0.5	0.5	0.5	0.6	0.5	0.2	0.2	0.2
K4	Complete Artificials (I.) with Dung	1.0	7	0.4	—	—	—	0.1	0.5	0.2	0.2	0.2
K5	Complete Artificials (I.)	1.0	—	0.4	—	—	—	0.1	0.5	0.2	0.2	0.2
K6	Complete Artificials (I.) without Phosphates	1.0	—	—	—	—	—	0.1	—	0.2	0.2	0.2
K7	Complete Artificials (I.) without Nitrogen	1.0	—	0.4	—	—	—	0.1	0.5	—	—	0.2
K8	Complete Artificials (I.) without Potash	1.0	—	0.4	—	—	—	—	0.5	0.2	0.2	—

* Half of each plot received 14 lbs. Grass Cuttings per sq. yd. in addition.

† The Top-dressing was applied in eight equal instalments.

§ J1a—J1d see footnote to Table 4, page 24.

Appendix C.

Dates of Cultural Operations during 1928—1929.

Crop.	Sown.	Potted into 60's.	Potted into 32's.	Planted out in borders.	First Mulching.	First Top Dressing.	First Fruit Picked.	Last Fruit Picked.
Cucumbers	Dec. 20 1928	Jan. 1 1929	Jan. 21 1929	Feb. 12 1929	Mar. 13 1929	——	Mar. 15 1929	Sept. 25 1929
Tomatoes	Dec. 20 1928	Jan. 23 1929	——	Mar. 7 1929	——	May 8 1929	May 29 1929	Oct. 28 1929

Meteorological Records, 1929.

1929.	Air Temperatures						Grass Temp.			Rainfall				Soil Temperatures		Hygrometer				Bright Sunshine		Barometer
	Mean		Absolute Max.		Absolute Min.		Av. Min.	Absolute Min.		Total Precipitation	No. of Days P'p'tn	Greatest Fall		Mean		Dry Bulb	Depres. of Wet Bulb	Relative Humidity %	Dew Point	Total No. of Hrs.	Daily Average.	
	Max.	Min.	Tem.	Date	Tem.	Date		Tem.	Date			Amt.	Date	1 ft.	2 ft.							
	°F.	°F.	°F.		°F.		°F.	°F.		Ins.		Ins.		°F.	°F.	°F.	°F.					Ins.
January	39	30	49	30th	21.5	13th, 26th	28.7	18	16th	1.57	18	.26	31st	36.4	38.7	33.3	0.7	86.6	32.0	33.4	1.07	29.900
February	38.6	24.8	52	1st	11.0	14th	23.2	8	14th	0.52	7	.21	2nd	34.8	39.2	30.0	0.5	89.5	31.2	57.2	2.04	29.936
March	58.4	32.1	75.5	30th	21.0	4th	30.1	19	1st, 4th	0.07	3	.05	3rd	39.0	38.6	42.2	2.2	78.1	38.3	144.9	4.67	30.310
April	54.9	34.8	75	20th	27.5	20th, 30th	32.7	23	30th	1.56	15	.39	29th	43.6	45.8	45.8	2.1	87.0	42.2	127.0	4.23	29.980
May	66.3	41.2	83	23rd	30.5	1st	39.3	26	1st	1.54	11	.31	5th	52.9	52.2	55.0	5.8	79.6	49.0	207.5	6.7	29.950
June	69.5	47.5	82	19th	40.0	8th	43.6	37	10th	1.31	14	.29	7th	60.2	58.5	59.4	4.6	74.0	48.2	206.6	6.88	29.351
July	74.6	56.6	90	20th	40.5	7th	46.4	37	7th, 25th	2.29	10	.65	20th	63.6	61.5	66.2	5.7	73.0	49.2	240.0	7.74	30.700
August	72.4	48.4	95	31st	43	2nd, 12th, 14th	45.1	39	2nd, 14th	1.38	11	.61	16th	63.4	61.6	67.2	5.2	78.5	53.8	198.3	6.40	29.960
September	71.4	49	89	8th	35.5	26th	45.6	33	26th	0.43	2	.27	29th	62.3	60.0	63.7	4.74	79.0	56.0	179.4	5.98	30.107
October	58.7	42	66	16th, 17th	27.5	26th	38.2	25	26th	3.44	14	.65	24th	49.4	52.3	53	1.73	84.6	46.4	105.0	3.38	29.820
November	49.7	33.8	59	22nd	22.5	14th	33.2	22	14th	5.69	22	.86	11th	45.1	46.6	44.4	1.2	87.4	41.7	57.6	1.90	29 689
December	51.2	31.2	58	14th	22	18th	29.2	22	18th	5.40	24	.77	6th	44.6	44.7	41.5	1.2	87.4	39	60.5	1.95	29.698

Total rain for year, 25.2 ins. No. of days precipitation, 151. Total bright sunshine for year, 1618 .9 hours.

DIAGRAM SHOWING ARRANGEMENT OF EXPERIMENTAL PLOTS, 1929.